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President's Page

One of the gratifying developments of geophysics in the present decade is the growing emphasis placed on studies of the Earth's interior. The stimulus for this enhanced effort arises from a variety of sources. Certainly the negotiations toward cessation of nuclear testing have brought sharply into focus the deficiencies in seismological knowledge and research. Likewise the IGY has generally directed attention to the advantages of a more complete understanding of the characteristics of Planet Earth.

Under these stimuli, geophysicists have organized a variety of activities of very considerable importance—programs that are certain to advance our comprehension of our planet in a major way. The seismological activities associated with Project Vela, which are summarized in this issue, represent a vital addition to the studies of waves in the Earth and to the interpretation of the meaning of their propagative behaviour in terms of internal structure of the Planet.

Closely related to the general seismological studies is the Upper Mantle Program now being planned as a worldwide effort by UGGI under the Comité Internationale Geophysique (CIG). The United States participation in this Program is now being developed by the Geophysics Research Board, under the National Academy of Sciences in intimate association with the AGU. This Program is a clear recognition of the need for close collaboration of scientists in the study of the top layers of the Earth if the baffling problems of tectonic structure are to be solved. Complete study of long sections using every geophysical method will be required to disclose the formations and forces that underlie the Earth's surface. Certainly the organized effort on the Upper Mantle Program is long overdue.

The first success on the *Mohole Project* has just been reported. Feasibility of drilling in the deep ocean floor, more than two miles below the surface, has been demonstrated with solid cores taken to a depth of several hundred feet below the deep floor. Sub-ocean geology is now brought within reach, and step-by-step we can anticipate reaching down to the Mohorovicic discontinuity, as the decade progresses.

Geodetic studies of the shape of the Earth stimulated by satellite methods bring a new order of precision to our knowledge of the Earth's form, and important auxiliary information on its structure. Likewise the IGY studies of the Antarctic continent provide new views on crustal deformation as a result of the ice-loading of the last great 'ice age.'

Theoretical studies are contributing their part with the development of methods of phase-equalization in seismology, and the experimental confirmation of Pekeris' predictions of body oscillations of the whole Earth. Altogether, man is awakening to the importance of understanding the nature of the Planet that is his home.

Also, of major importance to geophysics is the growing activity in geophysical observation on other continents. The whole Earth must be the laboratory of the geophysicist so that knowledge of all its parts is essential. Thus, the growing activity in Latin America, reported in this issue by J. Tuzo Wilson, retiring President of UGGI, represents an important addition to the general effort in the study of the Earth. Geophysicists everywhere will welcome the addition of the knowledge that our South American colleagues are bringing in increasing measure to our understanding of Planet Earth.

L. V. Berkner

Twenty-Third Award of the William Bowie Medal

Citation

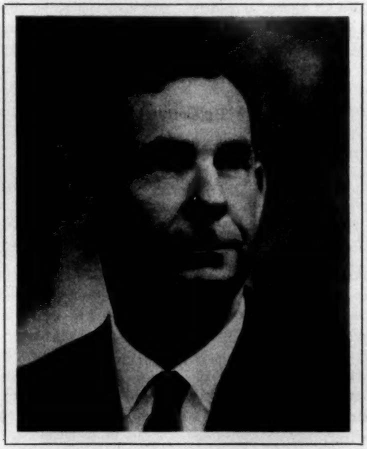
Prepared and Presented by LEASON H. ADAMS

Keith Edward Bullen has made outstanding contributions to geophysical science by his researches on seismology and the nature of the Earth's interior. He was born in Auckland, New Zealand, in 1906, and attended the University of New Zealand, where he was granted the degrees of M.A. (with 1st Class Honors) in Mathematics, and B.Sc. in Physics. In 1927 he was appointed Lecturer in Mathematics at Auckland University College. Dr. Bullen's interest in seismology arose especially through the occurrence in 1931 of New Zealand's worst earthquake, and his meeting with Sir Harold Jeffreys in Cambridge, England, the same year. On leave of absence from Auckland, he spent two years as a research student at St. John's College, Cambridge, working with Jeffreys. Subsequently the University of Cambridge recognized his ability in Earth science by awarding him the Ph.D. degree and later the Sc.D. degree.

From 1940 to 1945 he was Senior Lecturer in Mathematics at the University of Melbourne, which conferred on him a special M.A. degree. Since 1946 he has been Professor of Applied Mathematics at the University of Sydney.

His book *An Introduction to the Theory of Seismology* (First Edition 1947, Revised Edition 1959) has become recognized throughout the world as a basic text and reference book on the subject. To his credit he has two other important books: *Introduction to the Theory of Mechanics* (1949; 1959), and *Seismology* (1954).

Bullen is widely known for his studies on density variations within the Earth. The subject became of concern to him when he found it necessary to estimate the ellipticities of internal



Keith Edward Bullen
April 20, 1961

surfaces of constant densities; this required an improved knowledge of density in the Earth. His investigations have yielded a satisfying picture of densities in the Earth at various depths. The results of these calculations not only enabled him to complete the ellipticity corrections to travel times, but they also yielded values for the variations with depth of pressure, gravity, bulk modulus, and rigidity throughout most of the Earth. As a result of this work it became evident that between the crust and the core there must be significant chemical inhomogeneity or substantial phase change. In addition, the results lead eventually to useful conclusions concerning the internal structures of Venus and Mars, and the origin of the Moon.

His careful studies on travel times and density variations led him to formulate what has been called the 'Bullen Pressure–Incompressibility Hypothesis.' This amounts to assuming that within the Earth, at depths below 1000 kilometers, the incompressibility (reciprocal of bulk modulus) increases regularly and fairly smoothly as the pressure increases. This hypothesis led eventually to the inference that the inner core is solid. Additional work along this line indicated that the density at the Earth's center lies between 15 and 18, and led more broadly to the construction of the now widely used Bullen Earth Model B.

Other important subjects advanced significantly by Bullen were: Seismic Ray Theory; Structure of the Earth's Inter Layers and Outer Mantel; and Surface Seismic Waves. He was among the first to appreciate the significance of nuclear explosions for seismology. With Jeffreys he compiled the Jeffreys-Bullen tables of seismic-wave travel times. After more than 20 years these are still recognized as the standard curves for representing the propagation of earthquake waves in the Earth.

Bullen's services to science and especially to Geophysics have won him many honors. He is a Fellow of the Royal Society (London), a Correspondent of the Geological Society of America, a Foreign Member of the American Academy of Arts and Sciences, and a Past President of the International Association of Seismology and Physics of the Earth's Interior, of the International Union of Geodesy and Geophysics. He has received the Lyle Medal of the Australian National Research Council, the Hector Medal of the Royal Society of New Zealand, and the Walter Burfitt Medal and Prize of the Royal Society of New South Wales.

It was said sometime ago that the only 'dark Continent' now remaining is the interior of the Earth. Among all those who by scientific insight and controlled imagination have contributed to our knowledge by illuminating this 'dark Continent' a very special recognition is due Dr. Bullen, our most recent Medalist.

Presentation

MAURICE EWING

It is a great privilege to be here representing the President, Lloyd V. Berkner, who could not attend, and to hand this Medal for presentation to Professor Bullen. Bullen is distinguished for many reasons, and he has done as much as any other individual for the advancement of solid Earth geophysics. He is, indeed, a worthy recipient to add to the distinguished group of William Bowie Medalists.

Acceptance

KEITH E. BULLEN

(The medal was accepted on behalf of Doctor Bullen by Mr. T. B. Paltridge, Scientific Attaché of the Australian Embassy at Washington, D. C.)

Mr. President:

First, I need to express, as I have already done in a letter to yourself, my considerable awe on learning that I was to receive this most unusual award. My awe grew when I read the list of distinguished previous recipients of the William Bowie Medal, and I am acutely conscious of the great honour the American Geophysical Union has done me.

I want also to say how sorry I am that the pressures of a very large University have prevented me from being present in person at this ceremony, and to thank Mr. T. B. Paltridge of the Australian Scientific Liaison Office in Washington for kindly acting on my behalf.

The conditions of the award of the Medal refer to three criteria, on which I should like to comment briefly.

The first relates to contributions to fundamental geophysical knowledge. It is always flattering to be told by one's fellow scientists that some of one's work has proved to be significant. But I must confess that, in so far as this may apply to me, I have been favoured by fortune on at least several occasions.

Thirty years ago, as a raw young graduate in mathematics from my native New Zealand, I arrived in Cambridge, England, in search of research. There, I had the outstanding good fortune to be taken in hand by Sir Harold Jeffreys (another William Bowie Medallist), who literally brought me down to Earth and rescued me from a pure mathematical fate. He brought me to an understanding of the character of real applied mathematics, where context comes first and mathematics second. It was he who inspired me to work in seismology, work which later led me to wider geophysical interests.

My second major piece of good fortune arose out of the mundane matter of seismic travel-times. The need to allow for the Earth's ellipticity forced me to examine the Earth's density distribution, and almost by accident I stumbled across a method which appeared to enable me to set fairly stringent restrictions on allowable density values. It happened that this work carried with it values of the pressure, compressibility, rigidity and gravity in the Earth, and thence opened up a range of developments that kept me occupied for a long time, and took me into broad questions of the structure of the Earth, and even into planetary interiors.

At this point, I should like to acknowledge the compliment to me that Dr. Leason Adams, so noted a contributor on the Earth's density variation, should be presenting the citation.

I also have a debt to Nature for having apparently arranged some interesting compressibility properties in the Earth, which enabled me to link my earlier work with such notions as the solidity of the inner core. And Nature, so ruthless in last year's Chilean earthquakes, yet showed some kindness in providing, at the same time, evidence on the oscillations of the Earth which, on data so far to hand, appears to link up interestingly with my Earth Model B.

The second criterion for the Medal relates to co-operation. Here again I have been favoured, paradoxical as it may seem, by my antipodean location. Whatever disadvantages we antipodeans may suffer, there is the offsetting fact that one can travel from Australia to Europe by very many routes, including a wide choice across your North American continent. In the course of several journeys, I have in consequence been able to meet geophysical colleagues in countries both on and off the beaten track, and to get to know a little of their problems. The co-operation between them and me springs in large part from the many kindnesses I have received in many centres.

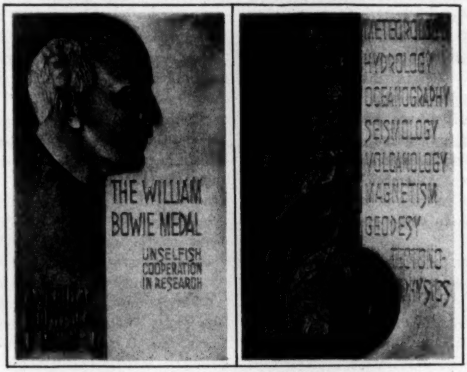
Finally, with diffidence, I come to the criterion of unselfishness. That I should be thought unselfish in my work has perhaps moved me more than anything else in this award. It is true that I have tried to assist a variety of scientists to an understanding of salient features of the interior of the Earth, as I see them. But quite often I have felt that the loads of correspondence that come my way, together with my limited secretarial support in a huge University undergraduate department, have forced me at times to be a little cavalier in some of my replies. I have tried to do my pathetic best, and can only take it that I am forgiven for the shortcomings of which I am all too conscious. I take it also that I have not been awarded too many black marks for the occasional bluntness of my remarks at international meetings where I have represented my country or where I have felt the urge to enter the arena on questions of administration and scholarship in Science. If I have sometimes been too blunt perhaps this will have been kindly attributed to preceding lack of sleep on long air journeys.

Gentlemen, through Mr. Paltridge, may I thank you most sincerely for thinking me worthy of receiving the twenty-third William Bowie Medal.

Previous Recipients of the William Bowie Medal

The previous recipients of the William Bowie Medal, with the dates of their awards, are as follows:

William Bowie (deceased)	1939
Arthur Louis Day (deceased)	1940
John Adam Fleming (deceased)	1941
Nicholas Hunter Heck (deceased)	1942
Oscar Edward Meinzer (deceased)	1943
Henry Bryant Bigelow	1944
Jakob Aall Bonnevie Bjerknes	1945
Reginald Alsworth Daly (deceased)	1946
Felix Andries Vening Meinesz	1947
James Bernard Macelwane (deceased)	1948
Walter Davis Lambert	1949
Leason Heberling Adams	1950
Harald Ulrik Sverdrup (deceased)	1951
Harold Jeffreys	1952
Beno Gutenberg (deceased)	1953
Richard Montgomery Field	1954
Walter Hermann Bucher	1955
Weikko Aleksanteri Heiskanen	1956
William Maurice Ewing	1957
Johannes Theodoor Thijsse	1958
Walter Maurice Elsasser	1959
Francis Birch	1960


THE WILLIAM
BOWIE MEDAL
UNSELFISH
COOPERATION
IN RESEARCH
METEOROLOGY
HYDROLOGY
OCEANOGRAPHY
SEISMOLOGY
VOLCANOLOGY
MAGNETISM
GEODESY
TECTONO-
PHYSICS

The William Bowie Medal (actual size 2" x 3¼")

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Status of the Seismic Research Program Recommended by the Panel on Seismic Improvement

CARL F. ROMNEY

Air Force Technical Applications Center
Washington, D. C.

AND

CHARLES C. BATES

Advanced Research Projects Agency
Washington, D. C.

In the September 1959 issue of the *Transactions* of the American Geophysical Union, Frank Press summarized the program of research recommended by the Panel on Seismic Improvement in its report, *The Need for Fundamental Research in Seismology*. Under the chairmanship of Lloyd V. Berkner, this Panel had been asked to report on the feasibility of improving the capability of the system for detecting and identifying underground nuclear detonations recommended in 1958 by the Geneva Conference of Experts. As a second task the Panel was requested to prepare recommendations on needed research in the field of seismology. Briefly, the Panel recommended a broad program of basic research in seismic wave generation, propagation, and detection, and also a more applied program for developing a prototype seismic detection system. The fundamental research program was to be supported by a program for modernizing and standardizing the seismographic equipment of a large number of seismograph stations around the world. In addition, it was recommended that a number of large chemical and nuclear explosions be detonated underground, in order to provide basic data necessary for the fundamental and applied research. This paper summarizes some of the principal actions that have been taken to implement the program reported on by Press.

Primary responsibility for carrying out the recommendations of the Panel on Seismic Improvement was accepted in April 1959 by the Department of Defense (DOD). The Atomic Energy Commission (AEC) was to be responsible for carrying out the underground nuclear explosions and the large underground chemical explosions that might be conducted at the Nevada Test Site.

At the request of the Department of Defense, the Air Force Technical Applications Center (AFTAC), developed detailed recommendations and a plan for carrying out the program of seismic improvement, and submitted this plan to the DOD on July 2, 1959. This plan was reviewed and recommended for approval by a special *ad hoc* Advisory Group of the DOD under the chairmanship of Frank Press; with slight modifications, it became the basis for the initial research and development work. On September 2, 1959, the Advanced Research Projects Agency (ARPA) was assigned the responsibility for research, experimentation, and development of systems to obtain, at the earliest practicable date, a system for the detection of underground nuclear explosions. At the same time, ARPA was given identical responsibility for work leading to a system for detection of high-altitude explosions. The entire research and development program was assigned the generic name Project VELA. In order to distinguish between the phases of the work dealing with detection of underground explosions and that dealing with detection of high-altitude explosions using either surface-based or satellite-based detectors, the project name was further subdivided into VELA-U (for underground), VELA-S (for surface), and VELA-H (for high altitude). Through an esoteric evolutionary process these names developed into VELA-UNIFORM, VELA-SIERRA, and VELA-HOTEL.

The most comprehensive report released to date on the background and status of the entire VELA Project is contained in the hearings on the 'Technical Aspects of Detection and Inspection Controls of a Nuclear Weapons Test Ban before the Joint Committee on Atomic Energy, 86th Congress, April 19–22, 1960.

Highlights of the VELA-UNIFORM Program are as follows:

FUNDING

The combined funds for fiscal years 1960 and 1961, available to the Department of Defense, amount to slightly over $41,500,000. In addition, the Atomic Energy Commission has available $16,500,000 for fiscal year 1961, for carrying out research explosions. The VELA-UNIFORM Program is broken down into seven tasks, with funds assigned to each task as follows:

Task 1	$ 3,375,000
Task 2	$12,365,000
Task 3	$ 9,600,000
Task 4	$13,348,000
Task 5	$ 173,000
Task 6	$ 602,000
Task 7	$ 2,175,000

DESCRIPTIONS OF TASKS.

Task 1: World-Wide Standard Seismological Network—This task calls for supplying standard calibrated seismological equipment to approximately 125 observatories throughout the world. Responsibility for carrying out this work resides with the U. S. Coast and Geodetic Survey (USC&GS), which was aided in selecting the standardized equipment and in developing policy on locations of stations by the Committee on Seismological Stations of the National Academy of Sciences. Each station will be equipped with three-component short-period and three-component long-period seismographs, recorders, timing system, calibration system, seismogram copying equipment, and a standby power source. Response characteristics of the short-period seismographs were selected as the result of a study of microseismic noise characteristics at twelve universities throughout the United States. It was found that a one-second period variable-reluctance seismometer driving a galvanometer with a 0.75 second period was about optimal at a typical university. The long-period seismometers will have adjustable periods in the 10- to 30-second range, and will drive galvanometers with periods of about 100 seconds. Seismograms from each of the selected stations will be available for general use by any seismologist through the USC&GS. The resulting data are expected to be of great importance as a basic source of information to the entire research program. For example, for the first time it will be possible to investigate such fundamental problems as the seismicity of the Earth and the energies of earthquakes with world-wide data from standard calibrated instruments. Most of the stations to be supplied with instruments have been selected from among approximately 250 stations that signified a willingness to participate in the program. The equipment is now being manufactured, and the first set of equipment will be installed during the summer of 1961.

Task 2: Research and Exploratory Development—This task includes all of the fundamental work on the generation and propagation of seismic waves, and the exploratory development of detection methods and instruments. It includes also a limited amount of work in hydroacoustic detection, an area of research not included in the report of the Panel on Seismic Improvement but, nevertheless, of significance in the detection of explosions. As of April 1961, nine universities, the U. S. Geological Survey, and three industrial organizations were participating in the work. At one or more of these participating organizations, work was under way on all of the individual research projects recommended by the Panel on Seismic Improvement, except that on the development of methods for deep-hole detection. Since that time, work has been started on deep-hole detection, and a large number of newly participating agencies are under contract to the government or are negotiating contracts with the government. Several significant seismological papers that report results of research have been published or are now in press. The Panel on Seismic Improvement noted that this area of fundamental research is the key to future improvements in the detection and identification of seismic sources. New ideas are needed. The work now under way is highly satisfactory, but should be expanded. Unfortunately, a large proportion of the requests received by the government are for support of projects that are not fundamental, but, rather, propose to investigate alternate approaches to jobs already accomplished. Refinements in measurement or in techniques for reduction of data are always useful, and such projects are being supported, but truly significant gains require a new understanding of the nature of seismic wave generation and propagation.

Task 3: Systems Development—The Systems Development task is under the direction of the Air Force Technical Applications Center. As part of this work it is planned to establish a network of about five seismographic stations equipped as recommended by the 1958 Geneva Conference of Experts. These stations will be placed on a grid of approximately 1000 kilometer spacing, as recommended for seismic areas by the Conference. One such station was completed and commenced operation in October 1960, by The Geotechnical Corporation of Garland, Texas. This station is known as the Wichita Mountains Seismological Observatory, and is located in the foothills of the Wichita Mountains, about 15 miles northwest of Lawton, Oklahoma. The site was selected because of the low microseismic background noise in the region, and because of the ready availability of facilities that greatly reduced the time required to establish the Observatory. The initial equipment includes an array of ten short-period Benioff vertical seismographs, two Benioff horizontal seismographs, a three-component installation of long-period seismographs with amplitude response peaked at about a 25-second period, a three-component installation of broad band seismographs with constant response between 1/10th and 10 seconds, and a three-component installation of intermediate period seismographs with response peaked at about 1 second. A schematic diagram of the station is shown in Figure 1. The station commenced regular publication of a monthly seismological bulletin starting with January 1961. A view of the main data control, time and power console in the central recording building is shown in Figure 2. The seismic information is recorded on magnetic tape and also on 16-millimeter photographic film. One of the key conclusions reached to date as a result of the operation of this station is that the seismograph peaked at 1 cycle per second is significantly less useful as a detection instrument than the short-period Benioff seismograph. The additional stations are scheduled for completion in late 1961 or early 1962.

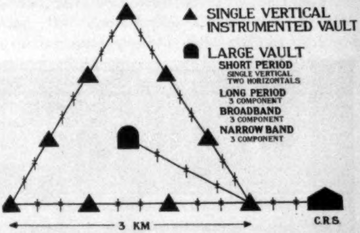

FIG. 1.—Schematic Diagram of Geneva Ten-Element Seismic Stations; seismometers in vaults are connected by wire lines to a Central Recording Station (CRS)

Following the recommendations contained in the report of the Panel on Seismic Improvement, a seismograph station of advanced design will also be constructed. The ultimate goal is the development of specifications for an optimum detection station to be used in an international control system for monitoring underground nuclear explosions. The station will have the basic complement of equipment described above, except that the array may consist of 30 to 100 detectors, and additional experimental seismographs will be installed for operational evaluation. This work is under the direction of United ElectroDynamics, Inc. of Pasadena, California. Since October 1960, extensive site explorations have been conducted and it now appears most probable that the station will be built a few miles north of Phoenix, Arizona. A second station of this type, to be in the southeastern United States, is also under consideration. Other work under the Systems Development task includes the design and evaluation of unmanned seismic stations, and the construction and operation of a calibration center, laboratory, and data analysis facilities. At the present time these latter programs are either in the advanced planning stage or contracts for them are being negotiated.

The network of seismographic stations, laboratory, and analysis facilities will be operated to provide information on the capabilities of such stations, when used in an international

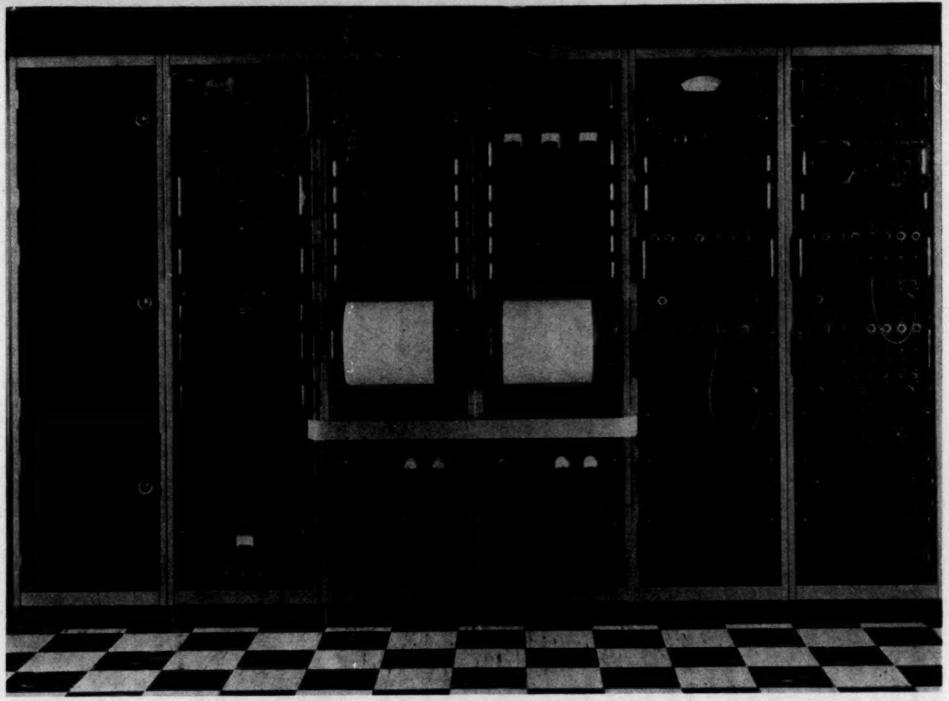

FIG. 2.—Data Control Panel at Wichita Mountains Seismological Observatory. Power and timing units are in racks on left, data monitor in center, signal control and calibration racks on right. Recording is accomplished on magnetic and photographic recordings not shown

control organization, to monitor adherence to a nuclear test ban. In addition, the data will be essential in identifying deficiencies in performance and thus identifying areas where research is required. All of the resulting information will be made available to qualified research workers in support of other programs.

Task 4: Nuclear and Chemical Research Explosions—As of April 1961, eleven to thirteen underground nuclear explosions and twenty-three chemical explosions were under consideration. The nuclear explosions, of course, would not be carried out without prior Presidential approval. Also, they would be conducted at depths sufficient to insure no risk from radioactive fallout, and would be conducted exclusively with nuclear devices of proven design. The United States has, in fact, offered to allow full inspection of the devices by the UK and USSR, as part of the coordinated research program it proposed. The research program would be divorced totally from the development of nuclear weapons. The research explosions as planned have identical objectives with those specified in the report of the Panel on Seismic Improvement, namely the determination of the effect of depth, geological environment, chamber size, etc., on the seismic signals generated. Of overriding importance, of course, is the need for data from explosions in order to prove out methods under development for distinguishing seismic waves generated by explosions from those generated by earthquakes.

The schedule for carrying out these explosions is indefinite at this time. The sites planned for such explosions are the Atomic Energy Commission's Nevada Test Site and one of two salt domes in southern Mississippi that are now being core drilled.

In the meantime, preparations are under way for recording the seismic data. The Defense Atomic Support Agency has developed plans for making measurements in the region of strong motion immediately surrounding each explosion. Six portable field stations, each capable of recording seismic information in the frequency range between 1 and 100 cycles per second, have been constructed by the USC&GS. Also, the Geotechnical Corporation is constructing forty portable field stations that will employ three-component Benioff short-period seismographs and three-component long-period seismographs of the Press-Ewing type. Recordings will be obtained both photographically and on magnetic tape. It is expected that a large amount of valuable data will be obtained also from stations operated by universities and other groups participating on a voluntary basis.

Task 5: Collation of Information—With the rapid growth of VELA UNIFORM there is need for a service that is capable of rapidly reviewing, collating, and abstracting the results of published and unpublished seismic research, and related technology, whether or not it is sponsored by VELA UNIFORM, and of disseminating such information to those who are interested in the program. Accordingly, arrangements have been completed for such services to be provided by a specially organized VELA Seismic Information Center (VESIAC) at the University of Michigan, Institute of Science and Technology.

Task 6: Special Short Term Studies—Included in this category are special studies that arise as needed to support the U. S. Government in its negotiations with the USSR and UK for a treaty on the controlled cessation of nuclear weapons tests. No specific examples were reported in the VELA Symposium.

Task 7: On-Site Inspection Techniques—This includes studies of the application of various geophysical techniques to the investigation of the site at which an unidentified seismic event occurred. Although no specific examples were given in the proceedings of the symposium, it has been stated on other occasions that these studies include the use of seismic refraction and reflection techniques in locating the crushed zone expected to result from an underground detonation, in the application of gravity, magnetic, and electromagnetic surveys, in measurements of ground subsidence, and in the application of any other scientific techniques that appear promising.

Seismological Program of the U. S. Coast and Geodetic Survey

LEONARD M. MURPHY

U. S. Coast and Geodetic Survey
Washington, D. C.

During the past year the Coast and Geodetic Survey received Congressional authorization for the construction of a seismological laboratory. Exhaustive tests of sites were conducted in areas from the Appalachian Range to the Rocky Mountains, to find a quiet location where the signal-to-noise ratio would be favorable for operating seismic detectors and calibrators with gains of 10^6 at 1 cycle per second. The most suitable areas were found in New Mexico, Arizona and Utah. Because of these choices logistical factors such as transportation, education, existing technical laboratories and living conditions were evaluated before the site was selected near Albuquerque, New Mexico, just south of the Sandia Military Base.

The laboratory will consist of an office building for the administration and processing of the seismographic data; a laboratory building equipped with modern shaking tables for measuring frequencies from 0.01 cps to 500 cps and peak-to-peak displacements of the table from 0.05 to 100 microns, and galvanometer, time control and electronic testing rooms; a building with modern instrument shop facilities; two modern surface vaults; and two vaults excavated about 75 feet into the granite of the Manzano Mountains and connected by a 40-foot tunnel at the rear.

The primary objective of the laboratory is to design, develop, test and calibrate sensitive teleseismic and strong motion seismographic instruments. In view of the extremely favorable location a complete family of seismographs, including short- and long-period detectors, strain equipment, and microbarographs will be operated continuously. These will be supplemented with the numerous instruments under test and development. For the present a minimum of analysis will be performed at the laboratory.

In the Washington office the method for epicenter determination has been quite successfully programmed for an IBM 650 operation. Since August 1960 all epicenter work has been done on the computer. The procedure is still being refined, and thoughts are being given to automation of the earthquake readings that are fed into the computer, and to the print-out of the results. It is hoped that the print-out will include all pertinent earthquake data and such related facts as station azimuth, distance and residuals. This epicenter service will be expanded greatly as soon as readings become available from the worldwide standardized seismographic network. At the present time more than 1500 earthquakes are being located annually; within a year or two this number should be increased several fold.

As part of the ARPA program the Survey is establishing an archives and data analysis center in Washington. Some of the immediate responsibilities will be to improve computer methods for epicenter determinations, investigate travel time anomalies, revise velocity curves for different focal depths, study magnitude and energy determinations, and evaluate methods for distinguishing earthquakes from artificial explosions. With the expansion of computer work in the Survey it is anticipated that many of these problems can be more readily analyzed and solved by this method.

In connection with other operations it is hoped to use the six mobile seismograph units, complete with geophones and small Benioffs, amplifiers, film and magnetic tape recording and readouts for the study of earthquakes in the Western States. These studies will include more precise epicenter locations, travel time anomalies, magnitude and intensity relations and energy determinations. In addition this equipment will be used in monitoring explosions and the results will be compared with those obtained from comparable earthquakes. Investigations continue in the analyses of strong-motion results from both nuclear and chemical explosions, and several papers have been published in technical reports of the Atomic Energy Commission and in scientific journals.

The Seismic Sea Wave Warning Service, which has been conducted by the Survey since the catastrophic earthquake of April 1, 1946, is continually being expanded. Originally it was intended to serve only the Hawaiian Islands and the U. S. Military posts in the Pacific Ocean areas; it is now serving the west coast of the United States, Canada, Alaska and many islands of the Pacific. In addition, special service is rendered Japan to provide data for the immediate locating of earthquakes a few hundred miles off the Japanese coast. Negotiations are now under way to include several countries in Latin America and in the southeast Pacific. Research and investigation are being conducted on the mechanics of tsunami wave generation by submarine earthquakes, and on the wave actions in confined areas such as bays and harbors.

Vol. 42, No. 2 TRANSACTIONS, AMERICAN GEOPHYSICAL UNION June 1961

The State of the Earth Sciences in South America

J. TUZO WILSON

Director, Institute of Earth Sciences
University of Toronto, Toronto, Canada

Background, Purpose and Scope—Between March 27th and May 4th, 1960, I visited the capitals of the ten republics of South America south of Panama, the headquarters of the Pan-American Institute of Geography and History in Mexico City, and a few other cities as far south as Punta Arenas. My visit was made on behalf of the International Union of Geodesy and Geophysics.

At all places, to the limit that time permitted, I called on institutes, university and government departments dealing with the Earth sciences and especially with geodesy and geophysics. At all places I was most kindly welcomed and most favourable impressed by the work in hand. Everywhere there was evidence of vigorous progress and of enthusiasm for exchanges with other countries.

This report is an account of the state of the work and of the people concerned in it. I visited most of the institutions and met most of the people mentioned, and I am grateful to them for the hospitable way in which they welcomed me.

Introduction

The contributions made to the early development of geodesy and geophysics by such men as Bouguer, Darwin, Humboldt, Montessus de Ballore and Sánchez are known universally, but the amount of the work carried out by them and by many other distinguished Earth scientists in Latin America is not sufficiently recognized. This is the more surprising in view of the many able Latin Americans who have gone abroad to study and stayed to work, and the many cooperative ventures which have taken Europeans and North Americans and more recently scientists from every part of the world to South America to make geographical explorations, prospect for minerals, search for oil, measure gravity and magnetism, study oceans and glaciers, examine volcanoes, probe the Earth's crust, test the atmosphere, sound the ionosphere, and make other investigations in company with local scientists.

In recent years this work has been given impetus by the rising interest in it evident in all these countries, through the co-operative efforts of the Pan-American Institute of Geography and History, and the International Geophysical Year, and by the assistance given to particular projects by such bodies as Missions from United Nations and UNESCO, the World Meteorological Organization, Inter-American Geodetic Survey, the U. S. National Bureau of Standards, the Carnegie Institution, the Rockefeller Foundation, and other similar bodies.

It may be that an ignorance of these matters has been a particular failing of my own, but I fear that I am not alone in this, and that communication between South America and the rest of the world is not as good as it should be. In this belief I spent the month of April, 1960, in visits to the capitals of the republics of South America to call on national committees of the International Union of Geodesy and Geophysics (IUGG) while I was still President of that body. I also called at the headquarters of the Pan-American Institute of Geography and History, in Mexico City, where I met many scientists. This paper is an account of the work that I saw in progress. The brevity of my visits will, I hope, excuse the omissions I have undoubtedly made. I much regret that lack of time prevented me from visiting the republics in Central America and in the Caribbean area, several of which have active Committees of the IUGG and have participated in the IGY.

Countries are described in alphabetical order, although I travelled south through countries bordering the Atlantic Ocean and North along the Andes. For each country, subjects are treated approximately in the following order: Geodetic work and cartography, seismology, meteorology, magnetism, oceanography, hydrology, volcanology, geology, exploration geophysics, studies of the ionosphere and cosmic rays, university work in geophysics, geophysical societies, and organizations concerned with international relations in geophysics. Any omission of a subject may be due either to lack of interest in that country, or to my failure to discover such interest.

Agencies responsible for, or related to, work in geodesy and geophysics in each country are listed at the end of the section for that country.

Acknowledgements—I should like to acknowledge the help of the Department of External Affairs in Ottawa, and the Canadian ambassadors and their staffs, who arranged the local details for my visits except in Paraguay, Bolivia and Ecuador in which countries I am beholden to the British ambassadors. It was possible for me to see so much only because of the excellence of these arrangements. The National Research Council of Canada generously paid my expenses.

I should like to thank especially all those who received me in each of the countries I visited, for the kindness of their welcome, the trouble they took to show me their work, and the generosity of their hospitality. Many have been kind enough to write subsequently and correct the draft of this report, but I have inevitably made other mistakes for which I apologize. I can only sum up by saying that the visit was an exciting and enjoyable experience from start to finish.

The Pan-American Institute of Geography and History

The Pan-American Institute of Geography and History (PAIGH) was founded in 1929 for the purpose of fostering knowledge and exchanges of information in geography and history and related subjects. Ing. Pedro C. Sánchez is regarded as the founder. The Institute is part of the Organization of American States (formerly the Pan-American Union). All twenty-one American republics belong to both bodies. Canada, which has long sent observers to meetings of PAIGH, has recently applied for membership in that body.

At present the chief officers are as follows:

President: Gen. Ramón Cañas Montalva (Chile)
Honorary president: Mr. R. H. Randall (United States of America)
Secretary-general: Arq. Ignacio Marquina (Mexico)

The three existing Commissions of the Institute are: Commission on Geography, located in Rio de Janeiro; Commission on History, located in Mexico City; and Commission on Cartography, located in Buenos Aires.

The secretariat is located in Mexico City. The last general meeting was held in 1955, in Mexico. The next general meeting was due to be held in 1960, in Lima, Peru, but has been postponed.

The PAIGH has been active in fostering geophysics and has a Committee on Geophysical Sciences, of which General Cañas is president, Ing. Monges López is vice president and M. Maldonado-Koerdell is secretary. This committee was strengthened in 1959 by merger with a committee on volcanology and a committee on oceanography. This large and active committee is busy preparing the way for a fourth commission within the PAIGH, and it is hoped that this new commission on geophysics can be established at the time of the next general assembly of PAIGH.

Geophysics has also been fostered by committees formed within the commissions of PAIGH, as well as those created by PAIGH as a whole. The Commission on Cartography has committees on gravity and magnetism (President: Ing. Monges Lópes, Mexico), on seismology (President: Rev. J. E. Ramírez, S.J., Colombia) and on tides (President: Sr. Marciano Balay, Argentina). The Commission on Geography includes a committee on climatology, and a working group on oceanography in Venezuela. It is thus apparent that many scientists are active in PAIGH in trying to foster geophysics and to raise the level of physical science in the organization.

PAIGH has initiated an experimental regional study of geography, history and related aspects of Ecuador. A trial investigation of Pichincha province (in which Quíto lies) has been started; this study is under the general direction of General Chiriboga. Reports on geography and on meteorology have already been received from General Paz y Miño and Andrade Marín, respectively.

Argentina

Geodetic control and mapping are the responsibility of the Military Geographical Institute. This large and well-equipped organization must be rated among the leading geodetic surveys of the world. It is housed in two large establishments in Buenos Aires. One is the headquarters for mapping; the other is a laboratory, copied from one in Potsdam, with temperature-controlled vaults and every facility for calibrating instruments, for absolute gravity experiments and for a time service. The Institute has a large staff of permanent civilian engineers and technicians as well as military personnel.

Because Argentina is predominantly flat, triangulation can be organized in regular patterns but many short lines are required. The plan adopted divides the country into a net of two degree squares measured from a central north-south line. About 25 per cent of the primary triangulation, 40 per cent of the levelling, and 25 per cent of the detailed mapping on 1/50,000 and 1/100,000 scales are complete. All the country is mapped on 1/500,000 scale. Because work was started at Buenos Aires and is being carried working outwards, the borders are not well surveyed.

Well-known members of the staff include, Ing. Civil D. Guillermo Riggi O'Dwyer, Ing. Helidoro Negri, Ing. Esteban Horvat, Agr. Pablo Dragan, Dr. Nicolás Beljajew, and Sr. Enrique T. Spiess.

Geodesy is taught at several universities, among others by Ing. Eduardo E. Baglietto, director of the Institute of Geodesy, University of Buenos Aires; Ing. Heliodoro Negri, Chief of the Institute of Geodesy, University of La Plata; Dr. Carlos V. Cesco of the University of San Juan; Ing. Jorge Loureiro of the University of Rosario; Ing. Rafael Sanchez of the University of Tucuman, and Ing. Carlos Gastre of the University of Mendoza.

Gravity observations have been made by the Military Geographical Institute, where Dr. Gualberto Ianini is making an absolute determination of gravity, by Ing. José Mateo of the Astronomical Observatory, La Plata, who is now working with Professor G. Woollard at the University of Wisconsin and by Ing. Enrique Levin of the Antarctic Institute. Many gravity observations have been made in the central region and some in the northern and coastal parts of the country.

Seismological stations in Argentina are operated by two agencies. The National Meteorological Service of which Sr. D. Valenzuela and Sr. Roberto C. Roldán are the seismologists, operates stations at Buenos Aires, Mendoza, La Quiaca, Jujuy and Deception Island, Antarctica. A new station is about to open at Pilar. All have Wiechert or Mainka instruments. Buenos Aires is also equipped with Press-Ewing and Sprengnether seismographs. The observatory of the University of La Plata, at which Professor Ing. Simón Gershanik is professor of seismology, operates stations at La Plata and Santiago del Estero; another station is about to be opened at La Leona, Santa Cruz, near Lago Argentina. The station at Santiago del Estero is equipped with Sprengnether instruments. At La Plata there are only Mainkas, but other instruments are to be added. Sr. Pastor Sierra and Sr. Enrique Jaschek are seismologists at La Plata and, with Professor Gershanik, carry out theoretical as well as routine work.

The National Meteorological Service is part of the Department of Aeronautics; it combines both civilian and airforce functions but is entirely civilian. The Director Lic. Francísco Lucio Fernandez is a member of the executive committee of World Meteorological Organization. A former director, Dr. Rolando V. García is now dean of the faculty of science at the University of Buenos Aires.

The National Meteorological Service was established in 1875 by the great Argentine President Sarmiento. It operates 200 synoptic stations, 25 pilot balloons, six radar wind or radiosonde stations, and four forecasting centres.

At laboratories on the outskirts of Buenos Aires a considerable research program includes the study of atmospheric electricity. Separate measurements are made of heavy and light ions, conductivity and potential gradient by Ing. Santiago Carbone. At Pilar and at San Miguél similar work is under the direction of Rev. Juan Bussolini, S.J.

The laboratory at Buenos Aires also has direct charge of measurements of total sky and direct solar radiation, which are made at several places. This work is under Ing. Julio V. Iribarne, who stated that he intends to start measurement of long-wave radiation soon. At the laboratory several physicists and chemists are engaged in fundamental research upon cloud physics, including measurements of the freezing points of different sized droplets of water containing various impurities, studies of the effects of nuclei on drop formation, and measurements of conductivity of ice containing various contaminating impurities.

The results of this research are being put to practical use in a test of hail prevention and weather modification at Mendoza. In this oasis of irrigated land they have installed 120 silver iodide burners, which are operated for 10 hours on each evening for which hail is forecast. It is hoped in this way to charge the air with 10^4 nuclei per square meter, and so to prevent large hail storms from forming. After five years it is intended to evaluate the program statistically.

There is also a small and strictly military Naval Meteorological Service, which operates two upper air stations in the southern part of Argentina and another in the South Orkney Islands, Antarctica. There is also an Army Meteorological Service.

In the University of Buenos Aires Dr. Hector N. Grandoso is Chairman of the Department of Meteorology, Dr. J. E. Muñiz is Professor of Meteorology, and Ing. Enrique Samatan is Professor of fluid mechanics. Dean Rolando V. García continues to take an active interest in the subject. At University of La Plata the Professor of Meteorology is Professor George Dedebant.

The University of Buenos Aires offers an excellent course for meteorologists. This institution has been recognized as a training center by the World Meteorological Organization, and many students come to it from other South American countries.

Hydrology is divided between the Meteorological Service, the Directorate of Water and Energy of the Ministry of Industry, and the Hydrogeological Service of the National Directorate of Minerals.

Glaciology was studied but little before the International Geophysical Year, but is now being actively pursued. All but a few of the glaciers in this country are retreating. Among those active in Glaciology are Dr. Corte (at present with the Snow, Ice and Permafrost Research Establishment at Wilmette, Illinois), Dr. Benito Colquin, and Dr. Cesár A. Lisignoli, who is now working in the Antarctic. The center for much of this work is in the very active Argentine Antarctic Institute. Dr. Otto Schneider is the head of the scientific department. This institute has excellent offices, laboratories and a library in a large house in central Buenos Aires. This organization is interested in all aspects of scientific research in the South Polar region, as its object is to study the nature of the Antarctic.

Geomagnetic observatories in Argentina are operated at La Plata, Trelew, La Quiaca, Pilár, Córdoba, and in the South Orkney Islands, the first two by La Plata observatory and the others by the National Meteorological Service. A new station is soon to be installed at La Leona, Santa Cruz. Observations are repeated every five years at 28 field stations, and several geomagnetic charts of Argentina have been compiled.

At La Plata observatory Prof. Leonidas Slaucitjs is professor of geomagnetism, and Sr. G. Lutzov-Holm is a senior geomagnetician in the Meteorological Service and director of the geophysical observatory at Pilár. In the Antarctic Institute Dr. Otto Schneider executed a large research program on the aurora australis during the International Geophysical Year.

Oceanography is the responsibility of the Naval Hydrographic Service, which has a fine building and active staff in Buenos Aires. This agency produces many charts, operates aids to navigation, maintains a dozen tide gauges, and operates a time service which is broadcast to the public.

Other separate time services for purely scientific purposes are operated by the University of La Plata and by the Military Geographical Institute.

In addition to their other extensive duties, the Naval Hydrographic Service operates the converted frigate 'Capitán Cánepa' which, during the past four seasons, has co-operated with Professor Maurice Ewing of Columbia University in carrying out seismic and other studies of the ocean floor in the Scotia Sea and off Argentina. The first results of these studies will soon be published.

Rear Admiral R. N. Panzarini teaches a course in physical oceanography in the University of Buenos Aires for students majoring in meteorology, geology and biology.

There are many extinct but no active volcanoes in Argentina. Professor Felix Gonzalez Bonorino of the department of geology, University of Buenos Aires and Dr. Horacio Harrington, now at University of Kansas, Lawrence, Kansas, are experts on them.

A geological survey, called the National Directorate of Geology and Minerals, has published, in recent years, both a geological map and a map of mineral occurrences.

The Yacimientos Petrolíferos Fiscales (Y.P.F.) is prominent in petroleum prospecting and production, although it has not a monopoly. Ing. Juan Zunino is the chief geophysicist and also Director of the School of Applied Geophysics at University of Buenos Aires. Ing. Rodolfo Martín is Professor of Applied Geophysics at University of La Plata.

Among those who were active in the IGY Committee for Argentina are Rear Admiral D. Enrique G. M. Grunwaldt, who was chairman of the working group on world days and communications, and is now Chief of Naval Staff; Lieutenant Commander D. Jose A. Rodriguez, who was the chairman of the working group on ionosphere; Captain D. Carlos A. Ibarra, Director of Naval Electronics; Dr. Adulio A. Cichini, who was chairman of the working group on cosmic rays; and Rev. Nilo Arriaga, S. J., who was chairman of the working group on solar activity. The IGY Committee operates a network of 10 ionospheric stations of which 2 are in Antarctica and one is aboard ship.

A considerable number of professors at several of the universities in Argentina have already been mentioned. The University of Buenos Aires, with 60,000 students (Rector Dr. Risieri Frondizi), and the University of La Plata, with 30,000 students are the largest, and are anxious–like all that I visited–for exchanges with other countries.

The Chairman of the National Research Council is the Nobel Laureate Dr. Bernardo Houssay.

Ing. Simon Gershanik, Professor of Geophysics, University of La Plata, has recently organized an Argentine Association of Geophysicists and Geodesists. The international representation in geodesy and geophysics is handled by the National Committee of the IUGG, of which General Juan Jose Nano is Chairman, and the National Committee for the IGY, of which the Acting Chairman is Admiral Panzarini.

Because of the activity and well organized state of these bodies and their keenness to assist, it was particularly easy for me to obtain the information here presented.

AGENCIES

Military Geographical Institute (Buenos Aires)
  Director-General: Gen. Juan José Nano
  Vice Director: Col. Eliseo Varela

National Meteorological Service (Buenos Aires)
  Director: Lic. D. Francisco Lucio Fernandez (also member of Executive Committee of WMO).
  Vice Director: Lic. Claudio Martinez
  Secretary: Ing. Roberto J. Brocqua

Naval Electronics (Buenos Aires)
  Director: Captain D. Carlos A. Ibarra

Naval Meteorological Service (Buenos Aires)
  Chief: Commander D. Luis Maria de la Canal

Army Meteorological Service (Buenos Aires)
  Chief: Major D. Luis M. Miro

Argentine Antarctic Institute (Buenos Aires)
  Director: Rear Admiral Rodolfo N. Panzarini

Naval Hydrographic Service (Buenos Aires)
  Chief: Captain D. Rodolfo H. R. Bagnati
  Chief of Nautical Department: Commander Oscar J. A. Ciarliotti
  Chief of Hydrographic Levels Department: Commander Juan Carlos Silva
  Chief of Oceanography: Lieutenant Ricardo O. Renella
  Chief of Antarctic Division: Lieutenant Commander Enrique J. Pierrou

Directorate of Geology and Minerals (Buenos Aires)
  Director: Dr. Roberto Tezon
  Chief, Hydrogeological Service: Dr. Cenar R. Vilela

Directorate of Water Energy (Buenos Aires)
  Director: Ing. Adriano Borus

National Research Council of Argentina (Buenos Aires)
  Chairman: Nobel Laureate Dr. Bernardo Houssay

Bolivia

Geodetic work and cartography are functions of the Military Geographical Institute. The Institute has good buildings and equipment, and has completed a primary-order geodetic net and first-order net of levels over the southwestern half of the country. Ties have been made with Péru, Brazil and Chile. Surveys are being extended, and mapping started, to the northeast, but these are handicapped by financial problems and by the loss of trained men to the petroleum companies who also have to produce maps, especially in the Amazon basin. The southwest half of the country is well mapped on 1/2M scale, the rest less accurately, and now that triangulation and levelling have been done, a series of maps on 1/250,000 scale is planned.

A line of over 1,000 gravity observations has been made from Arica, Chile, through La Paz to Corumba, Brazil, and another line is being surveyed now from La Paz to Argentina. Other scattered observations have been made in the south. As in most other countries of South America, international comparisons of the value of the acceleration of gravity have been made by Professor G. Woollard, University of Wisconsin; Dr. J. E. Jackson, University of Cambridge; and Dr. C. H. G. Oldham, California Standard Research Laboratories.

San Calixto Seismological Observatory at La Paz was operated by Rev. P. M. Descottes, S. J., from 1912 until last year, when he was succeeded by Rev. Ramon Cabré, S. J., who was trained in Spain and Strasbourg. Rev. Andrés Pedrón, S. J., a technician and a student, constitute the staff. In spite of difficulties with accommodation and instruments, this station has always been so carefully run that it has always enjoyed a great reputation. It cooperated fully in the IGY seismology program. When one sees the very limited facilities, one is all the more impressed by the statement made by Professor B. Gutenberg in his book, *Seismicity of the Earth,* that since 1913 this station had been 'the most important single seismological station in the world.'

Another station has been operated intermittently at Sucre. Short period instruments are being installed in cooperation with the Carnegie Institution at La Paz, Cochabamba and Chacaltaya to form a part of a net of a dozen stations in Bolivia, Péru and Chile which will record local earthquakes in an attempt to determine the thickness of the crust under the Andes. It will be recalled that Drs. M. Tuve and H. Tatel inaugurated this work using explosive charges.

Meteorological observations are taken at some 20 or 30 ground stations, but inasmuch as they are operated by several different organizations, it has proved difficult to coordinate their efforts and obtain uniform reports.

Sr. Jorge Saavedra of the Laboratory of Cosmic Physics in the University, who was formerly with the National Meteorological Service, is starting a study of solar radiation on the Altiplano; he hopes it may be possible to use solar energy there for house heating. At this Laboratory they would like to start radiosonde ascents to improve their cosmic ray research as well as for forecasting.

An interesting feature of the local meteorology is the extremely regular semi-diurnal atmospheric tide recorded on barographs at Chacaltaya Observatory. The pressure rises to about 555 millibars each day at 1100 hours and 2300 hours, and drops to 535 millibars each day at 0500 hours and 1700 hours.

Bolivia has no magnetic observatory, but two dozen field stations have been occupied and a magnetic chart of Bolivia has been printed. Most of this work was done by Sr. R. Salgueiro, who has worked with the U. S. Coast and Geodetic Survey and who is now with Yacimientos Petrolíferos Físcales Boliviano (YPFB).

The retreat of glaciers has been studied by Professor Jorge Munoz Reyes and Sr. R. Salgueiro.

No active volcanoes are known in Bolivia, but much of the geology has been studied, as mining is the chief industry in the country. Some years ago a geological map was published by Dr. Friedrich E. Ahlfeld, director of the Geological Service of Bolivia. A new edition of a scale of 1/1.5M has just been issued, with a text of 245 pages entitled *'Geologia de Bolivia'* by F. Ahlfeld and L. Branisa; it was published by Instituto Bolíviano del Petroleo, Casilla 401, La Paz, and costs $10.00.

At least three technical missions assist in geology. Dr. Pierre Butticaz of Switzerland is in charge of a United Nations Technical Assistance party, and Dr. Henry Mayer has been assisting under the United States Point IV Program. Dr. Thormann heads four geologists from the German Federal Republic.

As in Chile mining is the leading industry and several mineralogenic provinces have been distinguished, but in prospecting the search for petroleum is most active at present. These efforts are now being coordinated by a Bolivian Institute of Petroleum, which was founded at the end of 1958. Its board of twelve members represents all the oil companies active in Bolivia. The technical members include Alfonso Romero, general manager of YPFB (President): Enrique Mariaca, assistant general manager YPFB (Secretary): Miguel Tejada, chief petroleum engineer YPFB; Jorge Muñoz Reyes, professor of geology; Reinaldo Muñoz Reyes, technical coordinator for YPFB with private companies; Dr. F. Ahlfeld, director, Geological Survey; R. Salgueiro, Geophysicist, YPFB; Dr. J. Van Beek, general manager, Compania Petrolera Boliviana Shell, Limited, was a member but he has recently left Bolivia on transfer.

The Institute intends to publish a quarterly technical bulletin, of which the first number will be devoted to papers given at a recent symposium, including a paper on isostatic compensation in the Bolivian Andes, by B. Suttil. The Institute is about to publish a bibliography of Bolivian geology.

Bolivia was very active during the IGY and some of the chief work was done at the Laboratory of Cosmic Physics of the University of San Andrés, La Paz, of which the director is Dr. I. Escobar Vallejo, in 1960 a visiting professor at the University of Chicago. Besides a laboratory in La Paz, there is a cosmic ray observatory twenty miles outside the city near the top of Mount Chacaltaya. A road and first-order line of levels reach this observatory at a height of 17,536 feet, making it the highest permanently inhabited scientific laboratory in the world. Work was started in 1946 and has been pursued vigorously since 1952. In the observatory, which is equipped adequately with electric power and other facilities, Dr. N. Nerurkar, a UNESCO fellow from India, is making comparative studies of cosmic ray flux from east and west directions with Kondaikanal, India, and other stations. Two cubic meson telescopes are operated, and an underground counter has been installed in cooperation with the University of Mexico. Dr. J. Hersil is collaborating with Professor B. Rossi of M. I. T. in a search for very high-energy cosmic rays. A proposal to monitor gamma-ray showers is under consideration.

The Laboratory of Cosmic Physics also operated a C-4 ionosphere sounder near Chacaltaya until several short-circuits, caused by the thinness of the atmosphere, made it necessary to move the sounder to a lower elevation, at Overjuyo, a suburb of La Paz, where it is operating regularly under the direction of Dr. Rafael Vidaurre. He is carrying out trials of VHF ionospheric scatter radio transmission with Péru. One useful outcome of the IGY is the discovery of the practical application of this in equatorial communications.

Professors D. E. Blackwell and Mr. M. F. Ingham, of Imperial College, London, have been carrying out studies of the Zodiacal Light at the laboratory.

The principal university in Bolivia is the Universidad Mayor de San Andrés, of which the rector and vice rector are Dr. Pérez Ribero and Dr. Casto Pinilla, respectively.

The Institute of Geology at this university operates a regional school for geologists with United Nations support.

There are universities also in Cochabamba, Oruro, Potosi, Sucre, Tarija and Santa Cruz.

An active National Committee on Geophysics has recently joined the IUGG.

AGENCIES

Military Geographical Institute (La Paz)
Director, Col. Edmundo Beyer
Chief, Section of Astronomy: Major José A. Zelaya
Chief, Division of Geophysics: Major Salvador del Pozo
Chief, Division of Photogrammetry: Major Oscar Wilde Fernandez
(Chief, U. S. Army Mission: Captain H. L. Brogles)

Geological Service of Bolivia (La Paz)
Director: Dr. Friedrich E. Ahlfeld

National Meteorological Service (La Paz)
Director: Sr. T. Siles

San Calixto Seismological Observatory (La Paz)
Director. Rev. Ramon Cabré, S.J.

Bolivian Institute of Petroleum (La Paz)
Director: Sr. Alfonso Romero
Secretary: Sr. Enrique Mariaca

National Committee for IUGG (La Paz)
Chairman: Rev. Ramon Cabré
Vice Chairman: Dr. R. Vidaurre
Secretary: Sr. Raul Weil

Brazil

The National Commission on Geography of the Brazilian Institute of Geography and Statistics is the body primarily charged with geodesy and mapping. It is very active and has just produced two excellent atlases of the whole country on 1/1M scale; it is now planning to map the entire country on 1/100,000 scale. Geography is a very active subject in Brazil, and includes much that would elsewhere be called geophysics or geology.

About half of the country has been photographed from the air. A geodetic net and level lines already cover the southern part of Brazil; they are being extended north and west. In cooperation with Brazil the Inter-American Geodetic Survey is planning a geodetic connection along the northeast coast of South America. Level lines and gravity observations have been made across Brazil to Bolivia and along the ocean coasts, but as yet very few gravity observations have been made in the Amazon Basin. The whole program of geodetic work and mapping has received great impetus from the new policy of opening up the interior of Brazil and of building roads across it.

The Geographical Service of the Brazilian Army has prepared and published many maps on scales of 1/50,000 and 1/25,000 of frontier areas, of settled regions and of military reservations.

In São Paulo the provincial state Department of Geography and Geology has extended the national geodetic and level net and published a series of maps on 1/25,000 scale, but officials there doubted whether other provincial states had any equivalent organizations.

Geodesy is taught at the University of São Paulo by Professor Valdemar Lefevre, who is director of the Institute of Geography and Geology. At the university observatory, the director of the Institute of Astronomy and Geophysics, Professor Abino de Moraes, is an expert on positional astronomy and celestial mechanics. At the observatory Sr. A. Postoiev operates a Markowitz moon camera regularly and successfully.

The seismological station at Rio is in the grounds of the National Observatory. Dr. Lelio Gama, the Director, was trained as an astronomer, but operates a complete time service, and a seismological station which cooperates closely with Professor Maurice Ewing of Columbia University. The magnetic observatory at Vassouras, near Río, and the newly established observatory at Tatuoca, in the mouth of the Amazon, are also under Gama's direction. The officials at the Observatory would like to establish a third magnetic observatory in the center of the Amazon basin, where there is an isoporic focus, but this would be difficult and expensive. Of Dr. Gama's assistants, I met Ing. C. Lacombe (electronics) and Dr. Manning Burrate (equatorial astronomy). Another scientist is engaged in making magnetic and gravity surveys especially in the south of Brazil.

At the National Meteorological Service the assistant director, Dr. José Carlos Junqueira Schmidt, is a strong advocate of the existence of a relationship between sunspot cycles and weather.

The Naval Hydrographic service, in the Ministry of Marine, is located in a picturesque, former imperial palace on Ilha Fiscal, in the harbor of Río de Janeiro, where it has produced many hydrographic charts of the coasts and rivers of Brazil. Lieutenant Paulo Moreira da Silva, who commands the oceanographic ship, 'Almirante Saldanha,' and who was trained in London and Paris, and Lieutenant Augusta de Oliveira Montires, its former commander, are among the officers with the most training and greatest interest in oceanographic work.

The University of São Paulo, of which the Magnífico Reitor is Sr. Professor Dr. Gabriel S. Teixeira de Carvalho, is perhaps the leading university in Brazil in technical matters. It has recently established an Institute of Oceanography, of which Dr. Ingvar Emilsson, a former student of Dr. H. Sverdrup, is director. A 150-foot oceanographic research vessel has been designed, and it will be built in Norway. The Canadian Department of Transport provided considerable help with the design. The vessel will be air-conditioned and will carry a crew of thirty-two. The Institute occupies two large houses, and it has a considerable staff of scientists and a good library. Besides Brazilian government support, it has had assistance from the Rockefeller Foundation. Two oceanographic shore stations and tide gauges are also operated.

Others interested in oceanography are Dr. François Ottomann, director of an Institute of Marine Biology and Oceanography at the University of Recife, and Professor João José Bigarella of the Institute of Geology of the University of Parana.

Cruises made by Brazilian vessels show that the subtropical convergence, where the south-flowing Brazil current and the north-flowing Falkland current meet, lies in a fluctuating position off the province of Río Grande. Its location is important for fishing. A counter-current beneath the Brazil current has also been discovered and found to give rise to upwellings of cold, fertile water.

The Geological Survey of Brazil, which was founded over fifty years ago by the American geologist, Derby, is well known. The Survey and its splendid collections are housed in fine buildings overlooking Río harbour.

Ing. Alberto Ribeiro Lamego, the Director of the Division of Geology and Minerals in the Department of Agriculture, has just completed a new geological map of Brazil on 1/1M scale, and also a new geological map of South America on 1/5M scale. Both of these maps were issued in 1960; the latter was compiled as a project of the International Geological Congress.

Owing to the activity in opening up Brazil and in prospecting for oil and ores, many geologists have left the government service, but a party of German geologists under Professor William Kegel, retired director of the Prussian (?) State Survey, is mapping in northeast Brazil, under contract, and publishing the results in the survey bulletins.

Since 1950 the Departmento Nacional de Producão Mineral and the United States Geological Survey have collaborated in preparing 35 geological maps, on a scale of 1:25,000, of the iron and maganese deposits in central Minas Geras.

At the Institute of Geography and Geology of the provincial State Department of Agriculture of São Paulo, a few geologists, under the direction of Dr. Sergio Mezzalira, have started a series of 1/100,000 scale geological maps.

The chief centre for training geologists and exploration geophysicists is the Institute of the University of São Paulo, of which the director is the energetic Professor Viktor Leinz. Professor R. Kollert from Sweden teaches exploration geophysics under contract. Six other professors, and ten full-time assistants, including three American geologists from Point IV Program, are on the staff. The Institute has received help from the Carnegie Corporation. It has an excellent library, mineral collection and good equipment.

There is a Brazilian Geological Society, of which Dr. Ruy Ribeiro Franco of the University of São Paulo's Institute of Geology is president, and a Brazilian Association of Geographers, of which Ing. C. Lacombe of the National Observatory is chairman.

Brazil took an active part in the International Geophysical Year and operated an ionospheric sounder at São Paulo, which I did not see. I believe another has been opened recently at Natal.

There is interest in Brazil's island possessions. St. Paul's Rocks in the mid-Atlantic are occasionally visited by the Navy, but being only a few acres in extent and having no fresh water supply or harbours, little scientific work has been done and no permanent station has been established. Trinidade, which is also far offshore in the Atlantic, has been photographed and mapped and has a weather station. This island and an adjacent rock appear to be the tops of two distinct seamounts. Noronha Island has an air field and missile-tracking station. Rocas Island is another Brazilian possession. Charts of all these islands are available.

By a presidential decree of 1957 Brazil joined the International Union of Geodesy and Geophysics and a National Committee was established to consist of the representatives of these nine bodies.

I had the honour of attending the first meeting at which the representatives of these bodies were those whose names are listed here.

1. National Council of Geography of the Brazilian Institute of Geography and Statistics: Dr. Allyrio H. de Mattos
2. Directorate of Army Geographical Service: Col. Decio César
3. National Observatory of Brazil: Dr. Lelio Gama
4. Directorate of Hydrography and Naviga-

tion of the Ministry of Marine: Admiral Pedro Paulo de Aranjo Suzano

5. National Research Council of Brazil: Dr. João Cristovaõ Cardozo

6. Academy of Sciences of Brazil: Dr. Arthur Moses

7. National Meteorological Service of the Department of Agriculture: Col. João Luiz Maldonado

8. Water Division of the Ministry of Agriculture: (no representative)

9. Institute of Oceanography of the University of São Paulo: Dr. Ingvar Emilsson

AGENCIES

Institute of Geography and Statistics (Rio de Janeiro)
President: Col. Yurandyr Ferreira
National Commission on Geography
Secretary: Dr. Faissol

Pan-American Institute of Geography and History (Rio de Janeiro)
Commission of Georgaphy:
Secretary, Sr. Orlando Valverde

Geographical Service of Brazilian Army (Rio de Janeiro)
Director: General Adhimar de Oliverira e Croz
Chief of Staff: Col. Dacio Cesar

National Observatory (Rio de Janeiro)
Director. Dr. Lelio Gama

National Meteorological Service (Rio de Janeiro)
Director: Ing. Juan Luiz Vieira Maldonaldo
Ass't Director: Dr. Jose Carlos Junqueira Schmidt
Chief, Research Division: Sr. A. B. Serra
Chief, Meteorological Division: Dr. Jonir Barros
Secretary, Brazillian Committee, WMO, Dr. L. R. Ratisbona

Naval Hydrographic Service (Rio de Janeiro)
Director: Admiral Pedro Paulo de Arauno Suzano
Vice Director: Captain Alexandrino de Paulo Freitas Serpa
Chief, Hydrographic Division: Commander Maximiano Fonseca

National Department of Mineral Production (Rio de Janeiro)
Director-General: Ing. Avelino Ignacio de Oliveira
Director, Division of Mineral Production: Ing. Irnack Corvallo de Armarel

Division of Geology and Minerals (Dept. of Agriculture) (Rio de Janeiro)
Director: Ing. Alberto Ribeiro Lamego

National Research Council of Brazil
President: Dr. João Cristovão Cardozo

Academy of Sciences of Brazil
President: Dr. Arthur Moses

Institute of Geography and Geology, State of São Paulo (São Paulo)
Director: Dr. Sergis Mezzalira

National Committee for IUGG (Rio de Janeiro)
Chairman: Dr. João Cristovão Cardozo
Secretary: Dr. Ingvar Emilsson

Geological Society of Brazil
President. Dr. Ruy Ribeiro Franco, University of São Paulo

Association of Geographers of Brazil
Chairman: Ing. C. Lacombe

Chile

Geodesy and mapping are done by the Military Geographical Institute. This is a strong organization, well housed in three buildings, each from three to five stories high. The director, Col. Eduardo Saavedra Rojas, and all of his officers are graduate engineers.

A first-order geodetic net extends from Arica south to latitude 45 1/2°, and most of the country is covered by a second-order net. Twenty-eight astronomical fixes and Laplace points and 15,000 gravity stations are located along 7,000 kms of first-order levelled lines. Air photographs have been taken, and maps for the whole country have been published on 1/250,000 scale. A new series of maps on 1/100,000 scale has just been started.

Gravity measurements by this Institute, and by Edgar Kausel and Mateo Dragicevic of the University Institute of Geophysics and Seismology extend in a north-south line from the Peruvian border south to Osorno. A few east-west lines cross the country. There is fairly complete coverage between latitude 32° and 37° S.

Latitudes and longitudes are studied by Professor Moren of the National Astronomical Observatory. This observatory is getting fine, new buildings, and there are plans for a very large, new telescope to take advantage of the excellent 'seeing' conditions in parts of Chile, and to supplement the work of the large telescopes in the northern hemisphere.

The Institute of Seismology at the University of Chile was founded fifty years ago by Montessus de Ballore. Many volumes of his important studies of earthquakes are hard to obtain and are not known outside of Chile. His successor, Dr. F. Greve, is about to publish statistical studies of 5,000 earthquakes that have occurred in Chile since 1942. He has shown that, owing to tidal influences, twice as many earthquakes occur at 5 a.m. as at 5 p.m. Two years ago Dr. Cinna Lomnitz, a Chilean with a Ph.D. degree from California Institute of Technology, succeeded him as director and at the same time the Institute was enlarged and renamed the 'Institute of Geophysics and Seismology.' The central seismograph station is in Santiago. Ewing seismographs and Benioff strain gauges have been installed, but the latter have not worked well because of local instability in the rock vault.

Other stations are operated at Antofagasta (director, Rev. G. Saa, S. J.), Concepción and O'Higgins base in Antarctica. A temporary station is recording aftershocks of the 1958 earthquake at Maipo, east of Santiago and another station is being re-established at Copiapo. The station formerly operated at Punta Arenas was dismantled because of the high microseismic activity caused by storms. It is hoped to establish stations also at Valparaiso and Easter Island. My visit occurred just before the very serious earthquakes of May, 1960.

Three hundred observers throughout the country report noticeable earthquakes, but none of any consequence occur south of latitude 40°, except locally along the great fault zone followed by the Strait of Magellen. A party from the University of Chile has just been to Isla Mas a Tierra, one of the several Juan Fernandez Islands and the easiest to reach because of fisheries there. The party measured gravity and reconnoitred the interesting volcanoes and collected reports on shallow earthquakes, which are numerous. Ing. Luís Silva R. carries out seismic exploration work for this University Institute of Seismology. Dr. Lomnitz is interested in tracing the Mohorovičić discontinuity under the Andes and offshore. Two Russian astronomers are coming soon to work in Chile under an exchange agreement.

Meteorological work in Chile is primarily the concern of the Air Force, and seventeen meteorologists work under the direction of Cmdr. Sergio Bravo. LAN-Chile and Panagra airlines and the Hydro-electric Corporation also do some meteorological work.

During the IGY radiosonde stations at Antofagasta, Puerto Montt, and Quintero operated in cooperation with the United States; two new stations are being opened at Juan Fernandez Island and Punta Arenas. Year books have been issued since 1943, and a one-year course for meteorologists has been established in Chile. Other meteorologists have been sent abroad for training. A German meteorologist, Albert Müller, is acting as technical advisor.

The same division of the Air Force has also had charge of most magnetic work done in Chile. During the IGY a geomagnetic observatory was operated on Easter Island by three of the Air Force personnel, and new stations are planned for Santiago and Punta Arenas. Easter Island presents logistic problems because a ship calls only twice a year, for two days on each visit and because housing on the island is inadequate.

Observations to obtain magnetic data for charts have been made at fifteen field stations by the Military Geographical Institute.

Oceanography is studied by the Department of Navigation and Hydrography of the Navy. This Department, founded in 1874, publishes nautical charts of the entire Chilean coast, organizes aids to navigation, and broadcasts time signals.

Tide gauges were installed in 1941 at Valparaiso, soon afterwards at Punta Arenas, and later at five other places. It is evident that Punta Arenas is sinking and Valparaiso is rising relative to sea level. Surface isotherms off northern Chile have also been recorded and published since 1946.

During the IGY tide gauges were operated on Easter Island and Juan Fernandez Island, and the temperature and salinity of the water at the gauges were measured monthly to a depth of 135 meters. A long wave recorder was maintained on Easter Island in cooperation with Scripps Institution of Oceanography. Surface temperature studies were extended south to Antarctica. The Antarctic convergence was located. Bathythermograph observations were begun. Cooperation was initiated in the tidal wave warning service of the U. S. Coast and Geodetic Survey.

Since IGY the German oceanographer, Dr. Wilhelm Brandhorst, has been employed as advisor by the Ministry of Agriculture. From February twentieth to March twenty-first, 1960, the largest Chilean oceanographic expedition to date was mounted jointly by several organizations, and complete oceanographic observations were made at 116 stations on 14 profiles extending from the coast for distances up to 150 miles westward. A new ship is being provided by the United States for a regular oceanographic program to embrace studies of the Humboldt current and counter-current, the oceanography of the gulfs and channels of southern Chile, and the waters of the southeastern Pacific Ocean and Drake Strait.

The study of hydrology is important in Chile because of its many deserts, and glaciers, and its potential hydroelectric power. However, the program for hydrological work is not unified. Most of the work is being done by the National Electric Corporation, which maintains over 100 gauging stations, but water supplies for cities and for irrigation are handled locally. Recently the Air Force Meteorological Service has started to make observations at fourteen snow stations and thirty combined meteorological and hydrological stations. Interest in cloud seeding has been expressed.

Most of the work on Chilean glaciers has been done by private expeditions, and the results have been summarized by Louis Lliboutry, a French glaciologist who published *The Snows and Glaciers of Chile*, University of Chile Press, 1957. The Institute of Geography in the University of Chile, of which Professor Borde is the Director and Professor Humberto Barrera is an active member, is much interested in glaciology.

For the past year the Italian Professor Lorenzo Casertan has been in Chile preparing a report and bibliography on the volcanoes of Chile, for the series on active volcanoes of the world, being compiled by the International Association of Volcanology. Many groups of active volcanoes occur in the northern and central parts of the country.

Because of great mining activity several institutes and schools deal with geology. The recently-formed National Institute of Geology corresponds to a geological survey. In 1960, with the help of the government oil monopoly, the Empresa Nacional del Petroleo (ENAP), and other organizations, it published a completely new geological map of Chile on 1/1M scale, and a start has been made toward publishing 1/50,000 scale geologic quadrangle maps. The United States Point IV program geologists, under Dr. George Ericksen, are cooperating closely in this work. Plans include the publication of tectonic, metallogenic and water-supply maps. Some large and economically favorable alteration zones are being mapped in detail. Dr. Pierre Saint Amand is studying the tectonics of Chile. There is a large fault with right-hand displacement between Iquique and Copaipo. Another fault forms the south coast of the Gulf of Penas, and the Strait of Magellan follows a third. The great earthquakes of May 1960 occurred in central Chile, along two faults that strike north-south off the coast and along the Andean front, respectively. Other large faults occur in the Andes, but no continuous system of faults has yet been found to extend throughout the length of Chile.

The University of Chile has 17,000 students. The faculty of engineering has 1,200 students and includes institutes and schools of geology and geophysics. The Institute of Geology in the University of Chile is long established and well-known, but it is concerned with research into petrographical problems rather than with mapping. Teaching in the University is handled by a school of geology, of which Prof. Humberto Fuenzalida is director. The University also has an Institute of Geophysics and Seismology, an Institute of Hydrology, and an Institute of Geography.

The courses last six years and have high standards especially in theoretical work. There are also six smaller universities in other cities. No graduate work is given in Chile and all university degrees are professional degrees such as Ingeniero.

Exploration for petroleum is entirely in the hands of ENAP, of which the general manager is Sr. Fernando Salas. An oil field has been found in Tierra del Fuego. No drilling has yet been carried out in the central valley, although large gravity anomalies have been found by the

Institute of Geophysics and Seismology. Mineral exploration is in private hands and is helped by the very regular patterns of metallogenic provinces, but it is handicapped by the lack of detailed geological maps.

NASA minitrack stations, which I did not visit, are located near Santiago and Antofagasta, and a newly installed ionosphere sounding station is at Concepción. Cosmic rays are measured at The University of Chile.

There is an active National Committee of the IUGG.

The widespread interest in geophysics and geodesy and the ability of those in charge of the work were most impressive.

AGENCIES

Military Geographical Institute (Santiago)
Director: Col. Eduardo Saavedra Rojas

National Astronomical Observatory (Santiago)

Department of Navigation and Hydrography (Navy)
Director: Captain Alberto Andrade
Deputy Director: Commander Guillermo Barros
Technical Assistant Director: Commander Raul Herrera

National Institute of Geology
Director: Dr. Carlos Ruiz

Chilean Air Force Meteorological Service
Director: Commander Sergio Bravo

National Committee for International Union of Geodesy and Geophysics
President: Gen. Ramon Cañas Montalva
Secretary: Dr. C. Lomnitz

Colombia

Unfortunately my visit to Colombia was short and this brief account hardly does justice to the large amount of excellent work in hand in that country.

Geodesy, cartography and some geophysical work, are the responsibility of the Agustín Cordazzi Geographical Institute, of which Dr. Benjamin Villegas Robledo is the director. It was once a military but is now a civilian organization, and is housed in a splendid new building adjacent to the University. Among those on the staff whom I met were Sr. F. Guillermo Mendershausen, a geodesist; Sr. Alberto Pardo Pardo, chief of a division; Sr. Alfonso García Espinel, chief of the section on soils, and Sr. Ernesto Parra Lleras, chief of the division of geophysics and Sr. Garivito, in charge of geomagnetics.

I believe that the country is well mapped and that geodetic work and lines of levelling extend from Panama to Venezuela and to Ecuador. A gravity map of Colombia on a scale of 1/500,000 was published in 1960. It is based upon many thousands of observations made by the government and by oil companies. At the National University of Colombia, Professor J. M. Patino is professor of cartography; he is also on the staff of the Texas Oil Company.

Colombia has four seismic stations, located at Bogota, Chinchina, Fuquene and Galerazamba. I visited the Bogota station, which is operated by Rev. Father Jesús Emilio Ramírez, S. J. It is in a rock vault and is equipped with Weichert, Benioff and Sprengnether instruments and a U. S. Coast and Geodetic Survey accelerometer. All the seismic stations are in radio communication with Bogota at least twice daily, and have alarms so that they give very quick notice of larger earthquakes.

There are three principal universities in Colombia—the National University in Bogota with 8,000 students; the Jesuit University of the Andes, also in Bogota, with 5,000 students; and the University of Antioca.

At the National University an institute of natural sciences has a fine new building. About 20 students a year take geophysics, mostly in conjunction with geology. Of the members of the faculty, I met Father Ramírez and Sr. Durán, and a young Spanish structural geologist, Professor Manuel Julivert. Father Ramírez, who was educated in Colombia, at St. Louis University, and in Europe, has a fine Earth sciences laboratory, called the Geophysical Institute of the Colombian Andes, an excellent geophysical library, and a fine collection of Colombia minerals, meteorites and local tektites. Father Ramírez and Sr. L. S. Durán published a valuable book on geophysics and geology in 1957 entitled *Nociones de Prospección, Vol. 1., Sismica, Magnetica, Introduccion a la geologia.* Sr. Durán is a professor of geology and a geologist with the Texas Petroleum Company.

A second edition of the map of epicenters and of faults in Colombia has been published recently. At present the most active areas lie in the south and along the southern coast. Many small earthquakes occur at the foot of the Eastern Cordillera north of Bogota.

The National Meteorological Service is also a civilian organization. About 50 synoptic stations are operated.

The Geographical Institute maintains a magnetic observatory at Fuquene. The Director, Sr. Garavito, has prepared a new isomagnetic map of Colombia, on 1:500,000 scale, for 1958.5 epoch, based on 66 stations; declination, inclination, and horizontal intensity are all shown by different contours.

Colombia has no active volcanoes, but the geology has been studied extensively. The National Geological Service published a geological map of Colombia in 1945; a revised edition is contemplated. Several quadrangle geologic maps have been published recently.

Two men mentioned as experts on the geology of Colombia are Mr. John Bower, the Canadian vice president of Colombian Petroleum Company, and Mr. Willis Hatfield, a retired oil geologist.

An ionosphere sounding station on the university campus is under the care of Rev. Father W. Escobar, S. J. who is assisted by Sr. Enrique Sanchez, a technician trained in Brazil and Canada.

Professor Juan Herkrath of the faculty of physics in the University, is an expert on cosmic rays.

Colombia has long been a member of the IUGG and has a national committee, of which I attended a meeting. They had a large and well organized program during the IGY.

It was a pleasure to see, if only briefly, such active and efficient work in geophysics and related subjects.

AGENCIES

Agustin Cordazzi Geographical Institute (Bogota)
Director: Dr. Benjamin Villegas Robeldo
Chief, Division of Geophysics: Sr. Ernesto Parra Lleras

Fuquene Observatory (Fuquene)
Director: Sr. Clemente Garavito

Geophysical Institute of the Colombian Andes (Bogota)
Director: Rev. Jesus Emilio Ramirez, S.J.

National Meteorological Service
Chief: Sr. Roberto Torres

National Geological Service
Director: Sr. Fernando Paba Silva

National Committee for IUGG (Bogota)
Chairman: Rev. Jesus Emilio Ramirez, S.J.
Secretary: Sr. Roberto Torres

Ecuador

Precise geodetic work was started early in Ecuador by the famous French expedition of 1735 to 1745. Today monuments to Condamine, Godine, Bouguer, to their Ecuadorian assistant Maldonado (who published, in England, the first map of Ecuador), and to Ulloa and Juan, the Spanish geodesists who investigated their work, stand in the central park of Quíto. The geodetic net that they established served until 1950 as the control for 1/25,000 scale maps of Ecuador.

The excellence of early exploration and cartography in South America is illustrated also by a map that hangs in the museum of the Franciscan Church in Quíto. It was published in 1775 by D. Juan de la Cruz Caño y Olmedilla, and it shows the entire coast and all the important rivers of South America in great detail on a scale of about 1/5M. At that time Bering and Hearne were the only Europeans who had yet seen any part of the northwestern half of North America.

The Military Geographical Service has charge of mapping. It has completed a geodetic net and level lines along the coastal and Andean part of Ecuador, with connections to Colombia and Péru. A net from Ecuador across Brazil is planned, but the complete lack of roads in the Amazon basin of Ecuador, the scarcity of air fields, and the difficulty of navigating the fast, upper parts of the rivers make transportation a great problem.

The Service is an efficient and well-equipped organization. The Director and several other officers have been trained abroad. The vice director is working at present with the U. S. Coast and Geodetic Survey. The Service has a very complete supply of Zeiss equipment of all kinds necessary for mapping. Maps of Ecuador on 1/500,000 scale are complete, and a series on 1/50,000 scale is under preparation. A line of gravity stations extends along the Andes from Colombia to Chile, with stations at 2-km intervals. Another line extends to the coast, and there are a few other scattered stations.

One result of the new surveys has been to show that the equator is 732 meters south of the monument that is supposed to mark the place where the equator crosses the Pan-American Highway. A PAIGH resolution to erect an observatory there has not yet been implemented.

The three principal objectives of the measurement of these extensive arcs of triangulation, with their auxiliary lines of levelling, astronomic fixes of position, and gravity surveys, are that (1) they will provide a basis for calculating more precisely the dimensions of the geometrical spheroid that best fits the true shape of the Earth; (2) they will enable one to calculate the distances by which the geoid (the sea-level surface) departs from this spheroid; and (3) they will provide a base control for accurate mapping.

A project is in hand to photograph and map the Galápagos Islands again. It is a source of some confusion that the islands are known officially in Ecuador as El Archipelago de Colón and that all the major islands have two quite different names—one in Spanish, and one in English. The meanings of these two sets of names are not at all related.

The seismological station at Quíto is in the Astronomical Observatory in the center of the city. The director, Sr. Eduardo Mena, was trained in Paris, and has been at the observatory for thirty-three years. His assistants are Sr. Claudio Molina S. (at present with Dr. Lomnitz in Chile), and Ing. Galo Cascante, who has recently returned from Paris. A map of epicenters and tectonics of Ecuador was published during the IGY. The observatory is equipped with Sprengnether, Mainka and Bosch-Omori instruments, but the Sprengnether cannot be used because of traffic. The seismologists would like to build a new station outside of the city, and move the Omori instruments to a new observatory in the Galápagos Islands.

Meteorology is studied by a division in the Ministry of National Defense. A radiosonde station is operated at Guayaquil, and a pilot balloon station on San Cristóbal Island. I do not know how many synoptic stations are established, but it is evident that the climate varies very rapidly from place to place in the valleys among the Andean peaks, as well as between the windward and leeward sides of the Galápagos Islands. The southern sides of the four largest islands are wet and support a population of 2,500 people, but the northern slopes and the 98 uninhabited rocks are dry. Major meteorological disturbances occur when the ocean currents offshore depart from their usual behaviour and produce cool weather. Such an event lasted from 1918 to 1924 and caused great losses to crops. With a warning system other hardier crops could be planted. Similar climatic changes occur in Colombia and Péru.

For this reason it is obvious that a better knowledge of oceanography would be useful to Ecuador, and that the Galápagos Islands would be a good place to study both physical and biological aspects. These islands are much larger than is commonly realized. Isabela Island is 100 miles long. Volcanic peaks rise to 6,500 feet. There is an air field on Baltra Islet, adjacent to Santa Cruz Island, and it is proposed to establish a scientific station, and perhaps a satellite-tracking station on this island. The Galápagos Islands have no regular plane service but a ship calls about once a month. The islands have a notorious history and have long attracted interest of scientists. Recently British, French, German and United States expeditions have visited them. In 1958 a bibliography of the literature on the islands by Carlos Manuel Larrea was published by the Editorial Casa de la Cultura Ecuatoriana, Quíto. Maps and charts of the Islands are available from the Geographical Service, the U. S. Army Map Service, the U. S. Hydrographic Office and the British Admiralty.

The chief oceanographic work now being done consists of meteorological observations and surface temperature records, kept by the Ecuadorian Navy at nine stations on the coast and two on the Galápagos Islands. During the IGY tide gauges were maintained, in cooperation with Scripps Institution of Oceanography, at the weather stations on San Cristóbal Island and on Isla Genovesa (Tower Island). At times there was a difference in level of 1 meter between the two gauges owing to the Humboldt current, and temperature changes of as much as 7 degrees in a day, due to upwelling of colder waters, were also observed.

Another tide gauge is maintained at La Libertad, and for the past seven years a French company has maintained a pressure-type of tide gauge at a new port being built at San Lorenzo. The IAGS would like to install several more tide gauges.

Probably the best authoritive work on Ecuadorian volcanoes is still *Geografía y Geologia del Ecuador,* by Rev. Teodoro Wolf, S. J., which was published in 1892. Eruptions are frequent, on both the mainland and the islands. Lava flowed from Azúl volcano in southwest Isabela Island into the sea in June, 1959. The volcanoes on the islands (and hence the islands themselves) are arranged along a regular pattern of tectonic lines that run northwest-southeast.

On the mainland two, or perhaps three parallel lines of volcanoes form the main range of the Andes. Between the two western lines is the main upland valley in which Quíto is situated. On the most western line, the volcano Pichincha, which overlooks Quíto, has been active three or four times in the past 400 years. On the central line Cotopaxi and Tungurua are active. Three isolated volcanoes east of the main Andes are regarded by some geologists as a third line; of these Sangay and Reventador are active. Ash falls are frequent in Ecuador. Much of the soil contains ash layers near the surface. Severe eruptions and some of the world's strongest earthquakes are not uncommon.

The geology of Ecuador has been well mapped in a reconnaissance fashion by T. Wolf and others. A geological map and a report by Walter Sauer were published in Germany in 1950 and are still available from the University of Quíto. I was told that more recently a better map was printed by the Instituto Artístico Oreil Fussell, S. A., in Zurich, but its distribution has been prohibited because it does not show the boundary with Péru in an approved fashion. This is one of the major boundary disputes in South America, but there seem to be few countries which do not have such disagreements with their neighbours. Most of the others concern small parts of the frontiers, usually in those parts most difficult of access.

Oil production near Guayaquil meets domestic requirements, but there is so much recent ash cover that mining is important only in the southern part of the country, where volcanism diminishes, and below 3,000 feet, where erosion has cut into the ash beds.

A NASA minitrack satellite-tracking station is located near the Pan-American Highway a few miles south of Quíto. It is the most northern of four such stations in South America, all of which are along the Pacific coast. Mr. Cody Evans and Sr. Naptali Bonifaz are the senior American and Ecuadorian administrators.

I had no chance to visit the universities, but I met Ing. Julio César Granja of the Faculty of Engineering of the Central University. Engineering is taught also at the National Polytechnical Institute.

I attended a meeting of prominent geodesists and geophysicists, many of whose names have already been mentioned but which also included Colonel Marco Bustamante of the Ecuadorian IGY National Committee; Dr. Acosta Solis, a distinguished Ecuadorian botanist; Sr. Cristóbal Bonifaz Jijön, who is active in promoting science in Ecuador; and General Telmo Paz y Miño, a former director of the Military Geographical Service, who said that Ecuador had belonged to the IUGG in 1931 but that contact had been lost. There appeared to be a unanimous desire to re-establish closer connections, which was supported by Sr. Carlos Tufiño of the Ecuadorian Institute of Natural Sciences and Professor Jorge Andrade Marín of the Casa of Ecuadorian Culture.

It is evident that many leading Ecuadorians have a keen sense of the historic importance of Ecuador in the development of science, particularly in the expeditions of Condamine, Bouguer and Darwin; it is also evident that they are actively promoting a revival and increase in scientific activity in the country.

AGENCIES

Military Geographical Service (Quito)
- Director: Col. Bolivar Zurita Paz y Miño
- Vice Director: Lt. Col. Nelson Paz y Miño
- Chief of Section on Triangulation and Geophysics: Captain Osvaldo Vaca
- Chief of Section on Photogrammetry: Captain Medardo Teran
- Liaison Officer, Inter-American Geodetic Survey: Mr. George Richardson

Astronomical Observatory (Quito)
  Director: Sr. Eduardo Mena

Ministry of National Defense (Quito)
  Division of Meteorology
    Director General: Col. Galo Andrade Salas
    Vice Director: Luciano Andrade Marin

Ecuadorian Institute of Natural Sciences (Quito)
  Director: Sr. Carlos Tufino

Mexico

Geodetic work was started in Mexico in 1877 with the formation of the civilian Directorate-General of Geography and Meteorology. It was this organization that, between 1910 and 1917, and under the direction of Don Pedro C. Sánchez, surveyed the meridional arc through Mexico. In 1922 the report on this work to the International Union of Geodesy and Geophysics established the reputation of Sánchez and enabled him to play a leading role in the formation of the Pan-American Institute of Geography and History in 1929. The present director is Ing. Frederico Peña Aguirre, and a prominent member is Ing. Manual Medina Peralta. Formerly, this organization did much geophysical work. In 1945 the Commission of Military Cartography was founded. Both bodies carry on geodetic work and mapping. In 1947 an Institute of Geophysics was started within the National University of Mexico by Ing. Ricardo Monges López. This took over much of the geophysical work that, in other countries, is ordinarily done by government departments. The Institute is under the direction of Dr. Julián Adem and employs 100 persons, of whom 25 are scientists. It occupies 40,000 square feet of floor space—as much space in the university as physics or chemistry.

The measurement of gravity in Mexico has been carried out chiefly by Ing. Julio Monges Caldera (a son of Ing. Monges López) of the University Institute, in cooperation with the Inter-American Geodetic Survey. The University of Cambridge, the University of Wisconsin, and the Dominion Observatory of Canada have all made international comparisons of the value of gravity.

Ing. Monges Caldera has spent a total of twelve months recently on expeditions to make over 1,000 gravity measurements in Central American countries.

In Mexico there are eleven seismological stations, all under the University Institute of Geophysics. Ing. Jesús C. Figueroa is in charge of this work. The central stations is at Tacubaya, 15 km from Mexico City. It was established fifty years ago. A new map of the seismicity and tectonics of Mexico is being published later this year in the annals of the Institute. Two major earthquakes occurred in 1959. There was stated to be a need for more seismological stations in the Caribbean region and especially in Cuba, Hispaniola and Puerto Rico.

The Institute of Geophysics operates the only magnetic observatory in Mexico. It is located at Teoloyucan, 60 km north of Mexico City. A need is felt for another magnetic station in the region of Guatemala, San Salvador and Honduras.

A new magnetic survey of Mexico is planned, to be completed in 1963 or 1964.

A report was issued on auroras which were seen three times in Mexico and Cuba during the IGY. It was thought that auroras had been seen in Mexico only on three previous occasions, of which the most spectacular occurred in 1859, but search in old records and newspapers is disclosing a few more occurrences.

Meteorology is the concern of the Directorate of Meteorology and Geography of the Secretary of Agriculture and Husbandry. This agency shares a building with the Pan-American Institute.

During the IGY and with the cooperation of the U. S. Weather Bureau, four upper air stations were operated at Mexico City, Vera Cruz, Guadalajara and Merida, but, generally speaking, this field of study has not been very actively pursued in Mexico. Ing. Ernesto Domínguez is chief of the Gulf of Mexico center for meteorological studies, in Vera Cruz. This center does important work in forecasting hurricanes.

Hydrological studies in connection with irrigation are carried out by the newly created Hydraulic Resources Secretariat.

Glaciers occur on the three highest volcanoes in Mexico, and the first monograph of the Mexican IGY Committee was devoted to a description of them by Sr. J. L. Lorenzo. On behalf of his own Institute and others at Kiel, Hamburg and Heidelberg, Professor Karl Troll, director of the Institute of Geography of Bonn University, has recently offered to carry out more detailed glaciological studies.

Not much work in oceanography has been done by Mexicans, but they have cooperated with many expeditions of the Scripps Oceanographic Institution to the Gulf of Lower California and to the deep Central American trench, which lies off the Pacific coast of Mexico. However, the Institute of Geophysics also operates twenty tide gauge stations on both coasts of Mexico; and recently the Mexican Navy has given the Institute of Geophysics two contracts to undertake oceanographic work. The subject is being fostered by an Oceanographical Commission of the university, founded by Ing. Monges López in 1958 when he retired as director of the Institute of Geophysics.

In recent years most of the studies of the several active volcanoes in Mexico have been made by Ing. Frederico Mooser and Ing. M. Maldonado-Koerdell, who have published their findings in the *Bulletin Volcanologique*. Paricutin ceased activity in 1952 and Bercena Volcano had an intense irruption in 1952-1953. Since 1957 the only active volcano has been Colima, which lies on the coast on an extension of the Clarion Fracture Zone. Otherwise there is only solfataric activity on a few peaks.

Interesting studies of all aspects of the volcanic Revillagigedo Islands of Mexico which lie off the Pacific coast have been published by the Institute of Geophysics.

In 1955 a committee on volcanology of PAIGH was established, of which the secretary, Prof. Fred M. Bullard of the University of Texas, was the most active member. With support from the United Fruit Company, he made trips to Central America in 1955 and 1956 and wrote a report on the volcanoes there, which is being published in the reports of the International Geological Congress.

Geological work in Mexico reached a climax in 1956 with the holding of the International Geological Congress there. Ing. M. Maldonado-Koerdell and others are still editing the final parts of the proceedings of the congress. A geological map was prepared, of which a second edition has just been published.

Ing. M. Maldonado-Koerdell has also written a bibliography of the geology of the Central American states which is being published and he has pointed out the need for a handbook on the geology of these little-known countries. Perhaps the best existing reference is *La constitution géologique et la structure des Antilles*, by J. Butterlin, published in Paris in 1956.

Exploration for petroleum and minerals is active in Mexico. Petroleum is the monopoly of Pemex, of which the chief geophysicist is Ing. García Rojas, who also directed the International Geological Congress.

An important book on seismic exploration was recently published by V. A. Olkovich, entitled, *Curso de Sismologia Aplicada* (Editorial Reverte, South America, Mexico, 1959, 382 pp., diagrams). My attention was drawn also to a series of scientific translations from Russian into Spanish. By 1958 seven paper-backed volumes in Spanish had been issued in *Serie Ciencia y Tecnica* (Lauturo-Bolsilo, Buenos Aires,) of which five appeared to be by Soviet authors and two dealt with geophysical subjects, the ionosphere and polar wandering. They seemed to be sound little books, but naturally referred to Soviet work.

The Mexican Association of Exploration Geophysicists issues a bulletin.

An ionosphere sounding station at Cerrillo, in a valley near Toluca, is equipped with a National Bureau of Standards C-4 instrument. The station is under the direction of Ing. Carlos Nuñez, in turn under the Secretary of Communications and Transport.

Of the fifteen Mexican universities and twelve polytechnical institutes, the two largest by far are in the Capital. The National Autonomous University of Mexico, founded in 1955, of which Dr. Nabor Carrillo is Rector, and the Polytechnic Institute each has 40,000 students.

The Institute of Geophysics in the National Autonomous University has high standards and must be one of the largest anywhere. The director, Dr. J. Adem, is an engineering graduate of this University, has a Ph.D. in applied mathematics from Brown University, and has had two years post-doctorate study in Sweden with Dr. C-G. Rossby. The Institute publishes a bulletin, of which four volumes have appeared.

A striking building in the old city points up the early importance of Mexican mining—it is the magnificent stone 'Colegio de Mineria,' built in 1792, and now used as part of the engineering school. The courtyard contains four huge iron meteorites, two of which were found in 1561 by the Spanish explorer, Capitán Antonio de Espejo; they appear to have been part of a swarm.

Mexico played an active part in the IGY. A large part of the program was carried out by the university Institute of Geophysics. Good cooperation was obtained from the Secretary of Communications and Transport. Several reports have been issued; a final one is being prepared, and will deal with the entire Mexican program of the IGY.

The National Committee of the IUGG is very active. In 1961 it started publication of a journal, *International Geophysics;* an interesting feature is that it is printed in two languages.

The Mexicans are rightly proud of the large amount of splendid work they are now doing in all the Earth sciences and are most hospitable and kind in showing it to visitors.

AGENCIES

Directorate General of Geography and Meteorology (Mexico, D.F.)
  Director: Ing. Frederico Pena Aguirre

Commission of Military Cartography (Mexico, D. F.)
  Director: Ing. General Miguel Sanchez Lamego

National Autonomous University of Mexico (Mexico D. F.)
  Institute of Geophysics
    Director: Dr. Julian Adem
    Central Seismological Station(Tacubaya)
      Chief: Ing. Jesús C. Figueroa
    Geomagnetic Observatory (Teoloyucan)
    Commission on Oceanography (Mexico D. F.)
      Director: Ing. Ricardo Monges López

National Committee for IUGG (Mexico, D. F.)
  Chairman: Dr. Julián Adem
  Secretary: Ing. M. Maldonado-Koerdell

Paraguay

Geodetic work is under the direction of the Military Geographical Institute. Some early geodetic work was lost when the markers were destroyed, but recently a new mapping program has been initiated, and the first four maps of Asunción district, on 1/50,000 scale, have been produced with the assistance of an Argentine military mission under the command of Col. Javier J. Echevarrieta. Some gravity surveys have been made in the south.

Meteorology is under the Ministry of National Defense. About fifteen synoptic stations are operated, of which Asunción and Concepción operate for twenty-four hours a day and release pilot balloons. Two Argentinian meteorologists, Dr. Oswaldo F. Canziani and Ing. Albani provide technical assistance; they are members of a United Nations Mission, of which the chief is Dr. Oscár Schnake of Chile.

Geology and prospecting are the concern of the Ministry of Public Works and Communications. In this department a very active graduate in petroleum geology of the University of Texas, Ing. Ricardo Mazo, has charge of geological mapping and prospecting. With him are two geologists, Dr. Victor Díaz de Vivar and Dr. Gustavo Vera Morinigo, both trained at Asunción and São Paulo.

Under the United States Point IV program, Mr. E. B. Eckel of the United States Geological Survey recently prepared a geological map of Paraguay, which has been published by that agency.

In the past several American petroleum companies, including both the Pure and Union Oil Companies, have been active in geophysical prospecting, but the chief program underway at present is one of aeromagnetic surveying by the Prospec Company, in part of the Chaco.

The rector of the National University of Asunción, Ecmo. Prof. Dr. Crispín Insaurralde, and the dean of engineering, Professor Ing. Rogue Zaldivar, expressed their keen interest in technical exchanges, as did also Dr. R. Ramirez Pane, who supervises such exchanges. Of the existing exchanges, one of great future importance for Paraguayan science is the training of classes of secondary school teachers of physics and chemistry by the vigorous Dr. M. C. Alvarez Querol, who came from Spain on a UNESCO mission. The training appears to have been both thorough and practical.

AGENCIES

Military Geographical Institute (Asuncion)
  Director: General Francisco Vega Gaona

Ministry of National Defense (Asuncion)
  Director of Meteorology: Captain Dr. Teofilo Farina Sanchez

Ministry of Public Works and Communications (Asuncion)
In charge of Geologic Mapping and Prospecting: Ing. Ricardo Mazo

Peru

Owing to a change in airline schedules my visit to Péru was cut short, so that this report of it may be correspondingly inadequate, in spite of the enthusiastic help I received.

Geodetic control and mapping are done by the Military Geographical Institute. The work is done in cooperation with the Inter-American Geodetic Survey, Peru Project, of which the officer in charge is U. S. Army Lt. Col. Clarence F. Roberts Jr., and the chief engineer is Mr. K. W. Rinehart. Triangulation and levelling extend along the entire coast and into the Andes, but the Montaña is only beginning to be opened up. A Peruvian engineer Ing. Leondas Ocola, a member of the Huancayo Geophysical Institute, is now carrying out a gravity survey along all levelled roads.

Seismological work is centered about stations at Líma, Huancayo and Arequipa. Dr. Paul Ledig formerly with Carnegie Institution of Washington and the U. S. Coast and Geodetic Survey, and who was in charge at Huancayo, now operates a station in Lima; this station was equipped in 1906 with Weichert instruments and a U. S. Coast and Geodetic Survey accelerometer. At Nana (outside Líma) a new Benioff extensometer, provided by California Institute of Technology is operating well. At Huancayo Ewing long-period, Benioff and Wenner seismographs are in use, and a visible recording instrument and alarm system warns the Tidal Wave Warning Centre in Honolulu of serious earthquakes. At the University of Arequipa a new Institute of Geophysics is cooperating with Carnegie Institution, Bolivia, and Chile in a crustal research program. The Director, Dr. Anibal Rodriguez, was a geologist in charge of the seismological program at Huancayo during the IGY.

It is hoped that the Universities of Cusco and Trujillo may install seismographs shortly.

Several meteorological services in Péru have been operated by the Ministries of Aeronautics and Agriculture, by air lines and shipping companies, by the Guano Company, and by observatories, but meetings were planned for 1960 to coordinate their efforts under the chairmanship of Ing. Jorge Valdiva Ponce of the Ministry of Agriculture. Among other active meteorologists are Sr. Ernesto Roldán the former chief of National Meteorological Service in the Ministry of Aeronautics; Sr. Jorge Dextre, the chief meteorologist of the Guano Company and Sr. Guillermo Wagner, technical officer of ICAO Líma Office.

The Huancayo Observatory established in 1919 by the Carnegie Institution of Washington close to the magnetic equator, is famous for magnetic observations. In 1947 it became the Huancayo Geophysical Institute. It is now operated as an instrumentality of the Peruvian Government, with full operational autonomy under the direction of a board of Peruvians and representatives of Carnegie Institution, presided over by Ing. J. A. Broggi. It was very busy during the IGY, running four stations equipped with portable Askania variographs in a line across the magnetic equator, as a cooperative project with Carnegie Institution. Sr. Mateo Casaverde has been in charge of magnetic work for the past 13 years. In 1959 a new permanent magnetic station was opened at the University of Arequipa.

Oceanographic work has been under the direction of the Naval Hydrographic Service. This service prepares charts, and operates aids to navigation and several tide gauges. The Peruvian Naval ship 'Bondy,' 270 tons, is being used in the lighthouse service, and for oceanographic work that is being done in cooperation with the Council of Hydrobiological Investigations, of which there are five members from government Ministries and an advisory group from various scientific and technical services. A larger ship is now being built for this work, which will be considerably amplified under a special fund that has been granted by the United Nations for the study of marine resources.

In recent years Professor Erwin Schweigger started a faculty of oceanography at the Community University of Huacho on the sea coast north of Líma. The Guano Company is also interested in this subject.

Hydrology has been studied but little, except for the practical aspects of irrigation. The leading authority on the glaciology of Péru is Ing. J. A. Broggi who had glaciological observations made during the IGY in three parts of the Peruvian Andes. A moderate melting and recession was found to occur in the glaciers of the northern and central areas of the High Andes.

The situation regarding volcanology and geology in Péru has been somewhat confused recently. The well-known Institute of Geology directed by Ing. J. A. Broggi has been closed and the U. S. Geological Survey Point IV geologists who were co-operating with it have left.

During 1958 and 1959 the Instituto Nacional de Investigaciónes y Fomento Mineros and the United States Geological Survey collaborated in a project to evaluate the mineral potential of seven departments in southern Peru. A report in Spanish, and maps of geology and mineral deposits on 1:1M scale, were published.

A new association of geologists has been formed of which Dr. Tafur is president, and in which Dr. D. Las Casas is another active member. It may be that this group will take over responsibility for geological mapping. Peru has, of course, important mines and oil fields, and several holes have been drilled recently east of the Andes. Consideration is being given to engineering geology, soils, resources, and water power of some area east of the Andes, especially along the Mantaro River in central Peru.

An extensive study of the aeolian migration of the sea sands under the constant off-shore winds on the coast has been made by Dr. Jorge A. Broggi, his son Jorge Jr. and Dr. A. Indacochea (now deceased). Interesting and peculiar aspects of this migration are being discovered and work is being continued as time and funds permit.

During the IGY much additional work was started in Peru. A minitrack satellite-tracking station was established at Ancon; Mr. Cunningham, as NASA representative, is Director. Peruvian engineers from the Huancayo Institute are steadily being trained to replace Americans.

Under cooperative agreements with the National Bureau of Standards, Boulder, Colorado, Huancayo is a regional subcenter for ionospheric work; operators from other countries are trained here and stations at Huancayo, Talára, Chiclayo, Juliaca, Ilo and Chimbote (now being moved to Iquítos) are directed from this center. A new type of ionospheric radar sounder is being installed on the magnetic equator; it is based upon incoherent scatter from free electrons and uses peak power of 6 megawatts transmitted by some 6,000 antennas.

The following special cooperative studies are in progress: on cosmic rays, with University of Chicago; on back-scatter, with Stanford University; on whistlers, with Dartmouth College; on V.H.F. forward scatter in Argentina, Bolivia, Brazil, Chile, and Ecuador with the U. S. National Bureau of Standards; and two projects on fast recording of magnetic pulsations, with California Institute of Technology and Denver Research Institute. The U. S. Air Force supports research in solar activity, rapid-run H magnetograph, and night airglow which is automatically recorded by photometers registering in three different colors.

It is clear that the establishment of the Observatory at Huancayo has generated great interest in science in Peru, and that many Peruvians have been trained, most of whom started as engineers but some of whom have gone abroad for further study. It is now proposed that the Geophysical Institute of Huancayo should become a regional centre for equatorial geophysics in South America. At the same time, the enthusiasm and opportunities have reacted beneficially on the universities; some cases of this have already been mentioned. The University of San Marcos, which was founded in 1551 A.D., has a faculty of science of which Dr. Dario Acevedo, M.D., (a member of the Huancayo Board) is Dean, and who has written textbooks on physics. Also within the faculty there is an Institute of Physics and Mathematics, of which Dr. Fernando Tola is director. The National University of Engineering, in Líma, has a new nuclear and basic sciences faculty headed by Dr. Germán Morales Macedo.

A National Committee of the IUGG adheres through the Military Geographical Institute; the executives are Col. Guillermo Barriga, Ing. J. A. Broggi and Ing. A. Giesecke, Jr.

AGENCIES

Military Geographical Institute (Lima)
  Director: Col. Guillermo Barriga Meneses
  Vice Director: Lt. Col. Luis Montezuma Delfin

Huancayo Geophysical Institute (Huancayo)
Chairman: Ing. J. A. Broggi
Director: Ing. A. Giesecke, Jr.

Naval Hydrographic Service (Lima)
Chief: Commander Esteban Zimic

Ministry of Agriculture(Lima)
Meteorological Service
Director: Prof. Jorge Valdiva Ponce

National Committee for IUGG (Lima)
Chairman: Col. Guillermo Barriga
Vice Chairman: Ing. J. A. Broggi
Secretary: Ing. A. Giesecke, Jr.

Uruguay

My visit to Montevideo unfortunately fell on the first two days of Holy Week, which is taken as a complete holiday in Uruguay. All offices were closed, and I could get only a relatively small amount of information from the few scientists and engineers whom I was able to meet. Apparently there is close cooperation in scientific matters with Argentina.

Geodesy and mapping are handled by the Military Geographical Service. The Director has attended meetings of the International Union of Geodesy and Geophysics.

Others said to be interested in geodesy are Agr. Germán Barbato, a retired professor of Astronomy and Geography, former mayor of Montevideo and Chairman of the IGY Committee; Ing. Fernández Guido, Director of the municipal planetarium of Montevideo; Professor C. Etchecopar and Felix Cernuscki of the Astronomical Observatory of the University of Montevideo and the Institute of Topography and Geodesy in the faculty of engineering of the University.

Uruguay has no seismological or geomagnetic observatories.

The Meteorological Service has a forecasting centre and sixteen synoptic stations, of which two make pilot balloon observations. They hope to be able to expand their work to include radiation and radiosonde observations but are unable to do so at present.

The technical inspector, Professor Orfilio B. Rodriguez, studied meteorology in the University of Chicago; he was very helpful to me. The chief of the climatological section is Professor Juan Battione. Professors Walter Hill and Sr. Roberto Logarmilla of the University of Montevideo are said to be interested in solar radiation studies.

Hydrography is under the Ministry of Public Works. Hydrology is taught by Professor Ing. Carlos Nario, in the faculty of engineering of the University of Montevideo. Other interested engineers are Professors Germán Villar and Jorge Chabataroff. The work of the faculty of engineering at this University is well-known.

Little active oceanographic work is undertaken, but Captain Samuel Galimberti, a former director of the Meteorological Service, was trained also in oceanography, in England, and is well-informed on this subject. There is also a Naval Hydrographic Service and a Service of Oceanography and Fisheries.

There is a Geological Institute in the Department of Industry. At the University, Dr. Jorge Chabataroff is Professor of Geography and Geology. The chief mineral exports of Uruguay are marble and granite.

AGENCIES

Military Geographical Service (Montevideo)
Director: Col. Hugo Frigerio Herran (also Secretary of the National IGY Committee.)

Meteorological Service
Director: Captain Alfonso Delgado
Chief, Climatological Section: Prof. Juan Battione

Ministry of Public Works
Director of Hydrography: Ing. Conrado Sorrentino
Technical Assistant: Ing. Jose Ruzzetti

Naval Hydrographic Service
Director: Commander Carlos Lluberas

Department of Industry
Geological Institute
Director: Ing. Lorenzo Bugnet

National Committee on Geodesy and Geophysics
Chairman: Col. Hugo Frigerio Herran

Venezuela

The National Cartographic Branch of the Ministry of Public Works has completed a geodetic net across the northern part of Venezuela. This net has been tied to nets of Colombia and Trinidad. The Inter-American Geodetic Survey of the U. S. Army Map Service is planning to make Shoran connections to British Guiana as part of a net of trilateration along the northeastern coast of South America. Precise levels have been measured across the northern part of the country and tied to four tide gauge stations. Gravity has been measured along these lines.

Topographic maps are available for Venezuela and indeed for the whole of South America, on 1/1,000,000 scale, from the American Geographical Society and the U. S. Air Force. In Venezuela, the National Cartographic Branch, which has a fully-equipped mapping organization, has also published maps for the northern two-thirds of the country on 1/250,000 scale, although it was stated that height control is inadequate in some places. Other series are being produced on 1/25,000 scale for the settled regions, and on 1/5,000 scale for the cities. Thus it can be seen that remarkably good progress has been made in geodetic and topographic surveying in Venezuela in recent years.

A seismological station is operated at the Cagigal Naval Observatory, for which new buildings are in process of construction. Sr. G. Fiedler B. is in charge of the station.

The Venezuelan Air Force Meteorological Service operates twenty synoptic stations, one upper air radiosonde station and several hundred rain-gauge stations. During the International Geophysical Year the director of this service, Dr. Antonio Goldbrunner, issued a very fine climatological atlas of Venezuela, and an illustrated translation of a handbook of cloud types, and made a study of the northward movement in the early summer of the equatorial convergence that brings the rainy season.

An oceanographic institute has been started on the coast. Hydrology is studied along with irrigation, by the Ministry of Public Works; this work is very important in some parts of Venezuela.

Geophysical studies are extremely active in Venezuela in connection with exploration for oil, iron, and other minerals. Government licensing of this work is handled by the Ministry of Mines and Hydrocarbons, which also functions as a geological survey. At a meeting there I met the Directors of several bureaus listed, and Dr. Perez Mena, a geologist.

Geological maps of Venezuela are available on 1/1M and 1/2M scales, but they are somewhat out of date. Doubtless there are many more that have not been released by petroleum companies. This secrecy is not surprising in view of the fact that large regions of land, potentially favorable for petroleum, are still held by the government and have not been opened for leasing.

Two of the many petroleum companies active in Venezuela are the Creole Corporation, of which Mr. W. E. Franks, a geophysicist, is exploration manager, and Dr. Guillermo Zuloaga, a Ph.D. of Massachusetts Institute of Technology, in geology, and a Venezuelan academician, is a director; and the Shell Company of Venezuela, of which Dr. Hans P. Schaub is exploration manager, and Mr. A. Baber is geophysicist.

Aeromagnetic surveys of much of the interior of Venezuela have been made for private companies and for the government. One of these surveys, of 70,000 square kilometres in the El Baúl Apure area, was flown for a group of oil companies by Hunting Survey Corporation, and was recently released for publication on the occasion of the 1959 Venezuelan National Geological Congress. A mineral survey of 56,600 square kilometres in the northern Guiana Shield has been completed as the first part of a two-year program. This survey was carried out by Aero Service Corporation and Hunting Survey Corporation as part of an agreement between the Mene Grande Oil Company and the Ministry of Mines and Hydrocarbons.

Active efforts are being made to promote university, including technical, education. The Central University of Caracas has 18,000 students in fine new buildings. Geology and Geophysics are taught in the engineering faculty which has 2,800 students. Lectures in applied geophysics and geology are given by Ing. G. Lievans Pasade, who is translating M. Dobrin's *Introduction to Geophysical Prospecting* into Spanish, and by Dr. O. Renz of the Shell Company.

About 20,000 university students attend two private Universities (Santa María, and Andrés Bello, in Caracas) and universities in other cities. Of the latter the University of Los Andes in Merída is particularly well known.

Societies interested in geophysics include the Venezuelan Academy of Physics, Mathematics and Natural Science, the Venezuelan Chapter of the Society of Exploration Geophysicists, the Venezuelan Society of Geologists, and the

Venezuelan Association of Mineral and Petroleum Geology.

Venezuela participated in the International Geophysical Year through a National Committee, of which Dr. L. Calcaño was president. Many Venezuelans expressed a keen interest in joining the International Union of Geodesy and Geophysics. It is hoped that this can be arranged. Dr. L. Moleiro attended the 12th General Assembly in Helsinki as an observer.

The Directorate of International Organizations of the Ministry of Foreign Relations, is the branch of the Government concerned with international scientific relations. Among those active in this are Dr. Demetrio Boersner, subdirector; Dr. Francisco J. Duarte, academician and director of frontiers; and Dr. Juan Jones Parra, a leading figure in the Pan-American Institute of Geography and History and in the organization of Venezuelan scientific efforts.

I had the pleasure of meeting most of those named. All were most cordial and helpful both in arranging my visit and fostering the progress of good international relations in science.

AGENCIES

Ministry of Public Works (Caracas)
  National Cartographic Branch
    Director: Dr. Adolfo C. Romero
    Vice Director: Dr. Luis Calcaño
  Branch of Hydrology and Irrigation
    Director of Hydraulics: Dr. Armand Michelangeli

Cagigal Naval Observatory (Caracas)
  Director: Sr. José Abdala

Air Force Meteorological Service (Caracas)
  Director: Dr. Antonio Goldbrunner

Ministry of Mines and Hydrocarbons (Caracas)
  Director of Cabinet: Dr. Arturo Hernandez Grisanti
  Director of Geology: Dr. Gorgias Rafael Garriga
  Director of Mines: Dr. Felix Galavis
  Director of Geophysics: Sr. Leonardo Moleiro

Venezuela Academy of Physics, Mathematics and Natural Science (Caracas)
  President: Dr. Juan Francisco Stolk

Society of Exploration Geophysicists, Venezuelan Chapter (Caracas)
  President: Mr. E. J. Assiter

Venezuela Society of Geologists (Caracas)
  President: Dr. José Antonio Galaviz

Venezuela Association of Mineral and Petroleum Geology (Caracas)
  President: Dr. D. J. Shriner

Ministry of Foreign Relations (Caracas)
  Directorate of International Organizations
    Director: Dr. José María Machin Acosta
    Vice Director: Dr. Demetrio Boersner
    Director of Frontiers: Dr. Francisco J. Duarte

World-Wide Network of Standardized Seismographs

LEONARD M. MURPHY

U. S. Coast and Geodetic Survey
Washington, D. C.

Since the meeting of a Conference of Experts held at Geneva during the summer of 1958, the United States has been developing a program aimed at improving its technical capability for detecting and identifying nuclear detonations in space or underground. Shortly after this meeting, considerable doubt was expressed about possible capabilities because of new scientific information. The nuclear explosions at Nevada in late 1958 cast doubt on the reliability of reading first motions of explosions, and the decoupling theory of A. Latter, Rand Corporation, showed that the seismic signal from a device detonated in an underground cavity would be as much as 300 times less when compared to a tamped shot of the same yield.

When the full significance of these facts was realized by the government, the Special Assistant to the President for Science and Technology, at the request of the Department of State, appointed a Panel on Seismic Improvement to review the situation and to recommend appropriate action. The Panel, of which Lloyd V. Berkner was Chairman, produced a comprehensive report recommending, in considerable detail, a research and development program to improve detection capability. The Department of Defense was assigned the problem, and the Secretary of Defense gave the work to the Advanced Research Projects Agency in September 1959.

ARPA has organized its research into three distinct categories: Vela-Uniform—the use of surface detectors for underground explosions; Vela-Sierra—the use of surface detectors for atmospheric explosions; Vela-Hotel—the use of above-ground detectors for atmospheric explosions. Vela-Uniform, in which the Coast and Geodetic Survey is participating, has two tasks. One is to obtain better data on the nature, location, and frequency of occurrence of earthquakes. The other is to conduct a research program in seismology for a comprehensive understanding of the seismic signal generated by explosions, its signal transmission to locations at different distances, and the discrimination between earthquakes and underground nuclear detonations at a distance comparable to detection-station spacing.

During mid-1960 the Coast and Geodetic Survey was given the responsibility to up-grade the world network of stations by providing modern and uniform instrumentation to 125 stations. To advise the Survey in the choice of instrumentation and selection of the recipients, a committee of seismologists was established by the National Academy of Sciences–National Research Council. In considering the instrumental requirements, the committee was guided by the following: (1) the instruments should be of types that can be procured without extensive development; (2) three components should be recorded in every case; (3) the overall period response should be such as to cover the most useful part of the spectrum that can be recorded without resorting to equipment of special design. In view of these guide lines, the committee recommended two sets of three-component instruments, one short-period set with high magnification, and a relatively long-period set with moderate magnification. The three components of each set will be carefully matched in period response and magnification at each station. All seismometers—which will be electromagnetic—will record through galvanometers with conventional photographic recording drums. High quality clocks and radio receivers are to be supplied with the seismographs.

These guide lines were the criteria employed by the Coast and Geodetic Survey in writing the detailed performance specifications. No attempt will be made at this time to define the exact requirements since they are available upon request to the Director, U. S. Coast and Geodetic Survey, Washington 25, D. C. However, some of the more significant parts of the specification will be mentioned according to the following categories: (1) Short-Period System; (2) Long-Period System; (3) Recorders; (4) Timing System.

Short-Period System—The seismometers, vertical and horizontal, will be variable reluctance with a natural undamped period of 1 sec, ± 0.05 sec; coil resistance of 62.5 ohms; CDRX of 80 ohms; mass at least 100 kg; system magnification with peak greater than 100,000 at period of 1 sec.; sensitivity of 2 mv output per micron of Earth motion at period of 1 sec. They shall have built-in electromagnetic actuators for use in calibration. The calibrating deflection recorded on seismograms should be oriented so that it may be used for polarity tests. The short-period galvanometers will have an undamped natural period of 0.75 sec. ± 5%; internal resistance of 20–25 ohms; sensitivity of 10^{-8} to 10^{-9} amps per mm at 1 meter; critical damping resistance of 125–140 ohms; linear response of ± 5% of input current for angular deflections up to 0.1 radian. The galvanometer control will be used for matching the short-period galvanometer to the seismometer output. Variation in gain will be controlled in four step intervals of six decibels each, with no change in shape of response curve.

Long-Period System—The seismometers, both vertical and horizontal, will be moving coil with a natural period of 10 to 35 sec, and period stability of ± 2%; coil resistance of 500 ohms; mass at least 10 kg; temperature sensitivity with operating range greater than 10° C; pressure sensitivity of less than 1 mm deflection per psi at maximum gain with $T_g = 90$ sec, and $T_s = 30$ sec; magnification at least 4500 with loose coupling and critical damping. A pressure case will be provided for the vertical and a dual case, the inner one to insure windproofing and insulation will be provided for the horizontal. The calibration and polarity requirements are identical with the short-period system. The long-period galvanometers will have an undamped natural period of 100 sec ± 1%; internal resistance of 500 ohms ± 5%; sensitivity of 10^{-9} to 10^{-10} amps per mm at 1 meter; critical damping resistance of 400–3500 ohms; the control unit will be used for matching long-period galvanometer to the seismometer output. It will provide adjustable attenuation to the seismometer output signal to the galvanometer while maintaining a constant 500 ohm output and input impedance at all attenuation settings.

Long- and Short-Period Recorders—The recorders will have single or triple drums according to space available in seismic vaults. They will have recording speeds of 15 and 30 or 60 mm/min; synchronous motor drive; photo sensitive paper and recording time of 24 hours.

Timing System—Crystal clock control will be provided with a time accuracy of 5 parts in 10^7. The clock output will be used for driving the recorders and for controlling a programmer that impresses time marks on the records. The clock power output is 25–30 watts at 112–125 volts and 60 cps. A time pulse amplifier will be used to impress, automatically, one second radio time pulses as transmitted by U. S. and International Radio Times Signal System. The radio for detecting the signals will have 6 crystal controlled fixed frequency channels. The stability will range from .01% at 100 kc to less than .001% at 29.7 mc.

The power supply for the entire system will be 24 volts (d.c.) to operate the transistorized timing system, and the light source lamps of the recorders. A 24-volt storage battery will be on constant floating charge from a battery charger operating on the local power source. This battery will furnish power for 12 hours when local power supply fails.

The prime contract for the construction of this instrumentation was awarded to the Geotechnical Corporation, Garland, Texas on March 20, 1961, with a delivery date for the first 5 sets of instruments in 150 days, and for the entire 125 sets in 420 days.

In selecting the stations that would receive this modern equipment two criteria were generally applied, namely, the research potential and the geographical distribution. For further information about the selection reference is made to Specifications for a World-Wide Network of Standardized Seismographs, National Academy of Sciences, Washington, D. C. Before the delivery of the first instruments it is planned that all recipients will be selected. At the present time 114 stations have been approached regarding the installation and operation of this equipment.

The Survey will deliver the equipment to the stations and will install and check its operation. It is expected that 3 to 4 weeks will be adequate for this work, which will include instructing the personnel in the maintenance and the reporting of the results. The installation of all equipment will be completed by the end of 1962. Each recipient will receive full title to the equipment, with the understanding that the seismograms will be available to all responsible scientists for research programs. The Survey is requesting that each station send the original seismograms to Washington for use in establishing an archive center, where the records can be reviewed by the Survey for the purpose of troubleshooting instrumental operations, and by seismologists for use in research projects. It is planned that the records will be available, to interested scientists, as photographic copies, on 35 mm film, magnetic tape, and possibly in digitized form. More details about the archives and reproduction policy will be announced later this year.

Report of Committee of The Upper Mantle and Crust Program

LEONARD M. MURPHY, *Chairman*

At the Executive Committee Meeting of the American Geophysical Union on October 22, 1960, President Lloyd V. Berkner appointed an *ad hoc* Committee of the Upper Mantle and Crust. This committee, consisting of the Presidents of the Sections of Seismology, Tectonophysics, Geomagnetism and Aeronomy, and Volcanology, Geochemistry and Petrology, and the Reporter for Seismology to CIG, was to make recommendations regarding American participation in the Upper Mantle and Crust research program proposed at the XII Assembly of the IUGG, held in Helsinki, Finland in 1960.

The objective of this Committee was to work out a broad plan for a cooperative program, involving research in a number of places, and using standard methods of procedure, in a form that might greatly advance our knowledge of the Upper Mantle and Crust.

The initial action of this Committee was to query many organizations, both private and governmental, that are actively engaged in geophysical work, in order to ascertain how they might contribute to this special investigation. The responses, which were prepared in report form and distributed in January 1961, were very enlightening and, in general, reflected the high order of research being conducted in the United States. After this report was prepared it was realized that some organizations had not been contacted, but it was felt that much of their work had been covered in the American Report prepared for the Helsinki Assembly of the IUGG; at least, sufficient information was available for the guidance of the Committee's efforts.

At the CIG Meeting in Paris in January 1961, attended by Frank Press (the CIG representative in Seismology) and L. M. Murphy, a meeting of the 'Working Group' of the Upper Mantle Project was held. Besides the two United States scientists, this meeting, of which V. V. Beloussov was Chairman, was attended also by P. Tardi, T. Nagata, G. Laclavere, J. Gogel, and S. K. Runcorn. Beloussov presented a list of problems that might be appropriately considered for investigation. Some of these problems related to shields and stable zones, continental margins, island arcs, deep ocean basins, mid-ocean ridges, and island seas. It was the desire of the Committee that some specific problems would be selected for study, not only by organizations within a given country, but also by other countries through well planned coordinated efforts.

The CIG committee recommended a meeting of a Working Group in early 1962 to select and define the specific investigations to be conducted. The greatest efforts should be in the coordination of research work now being conducted, in the identification of areas where additional investigations should be encouraged at national or international level, and in the procurement of funds and the selection of organizations to conduct them. The suggested time schedule for the program is from January 1, 1962 through December 31, 1964. Three years should be devoted to a special effort on field observations, and the subsequent years, similar to the IGY effort, should be devoted to the interpretation of the results.

In February 1961, an informal meeting was held by a number of geophysicists in the Washington area, including the Chairman of the *ad hoc* Committee, who are interested in this particular study. Many of the participants were members of the recently appointed Geophysical Research Board (GRB) of the National Academy of Sciences. Merle Tuve, who acted as chairman, pointed out the need for guidance to the GRB in deciding the course of action that the United States should take in promoting this international program; he felt that any projects suggested and undertaken by the United States should be practical and have reasonable assurance of successful completion. Among the suggested subjects in these categories were the following: the establishment of high pressure measuring equipment, similar to that operated by Prof. Francis Birch, in several laboratories around the world; how to further the efforts of the Moho Project; the conducting of an inventory of the sediments by using the test drill rig of the Moho Project; the establishment of a network of gravity stations with longitudinal spread to study the longitudinal harmonics of the gravity potential; and how to further the worldwide seismographic standardization program with the strategic location of long-period seismographs. Together with the report of the *ad hoc* Committee these ideas will be presented to the GRB for developing the American program.

During the Forty-Second Annual Meeting of the AGU two papers were presented on the Upper Mantle and Crust, followed by a round table discussion, led by Patrick M. Hurley and L. M. Murphy, with invited participants. It is anticipated that a number of ideas will be forthcoming from this discussion which can be used by the Geophysical Research Board in formulating a U. S. program for presentation to the IUGG. When the report of this round table discussion is presented to the President of the AGU the work of this Committee will be terminated.

Reviews

J. G. D. PRATT, Reports of Trans-Antarctic Expedition 1955–1958: No. 2, *A Gravity Traverse of Antarctica*, 22 pp., 12 s. 6d; No. 3, *Seismic Soundings Across Antarctica*, 69 pp., 30s; No. 4, *Tides at Shackleton, Weddell Sea*, 23 pp., 12 s. 6d. Trans-Antarctic Expedition Committee, 22 Gayfere St., London W1, England, 1960.

No. 2—A Gravity Traverse of Antarctica

This report presents the gravity results obtained with a Worden gravimeter along the track followed by the British Trans-Antarctic Expedition from the Shackleton Base, on the Weddell Sea, to Scott Base, on the Ross Sea, via the South Pole. The gravimeter, loaned to the expedition by the University of Wisconsin, was a single dial Worden instrument having a range of about 1000 mgals and a sensitivity of 1.2600 mgals/vernier scale division. The report is particularly valuable in that it brings out the difficulties of calibrating a gravimeter adequately. Prior to going to Antarctica, the instrument was calibrated in the British Isles on a closed loop against pendulum gravity bases located at Teddington in England, and Edinburgh and Aberdeen in Scotland. The range in gravity covered was 503 mgals. The derived calibration differed by more than 3 mgals/1000 from the value determined in a similar fashion in the United States. The traverse across Antarctica embraced 192 sites. The base value adopted for the starting point at Shackleton was the preliminary value established by the University of Wisconsin on the basis of a La Coste gravimeter connection by ship from Punta Arenas, Chile, and Buenos Aires, Argentina. Instrumental drift was determined on the basis of that observed at each base stop over a 12 to 20-hour period. The derived composite drift was then adjusted to give the best fit to control base values at Southice, the Pole Station, and Scott Base. The Southice control value was determined from a closed loop connection, as established by air, to Shackleton. The Pole and Scott Base values used were those established by the University of Wisconsin. On the basis of the reliability of these various control points, the values of gravity determined are probably reliable to about 5 mgals. No anomaly values are given because it had not been possible, as of the time of publication, to obtain reductions of the meteorological observations for the accompanying elevation values. However, the geographic position, the observed values of gravity, and the author's estimate of reliability at each station are tabulated. Despite its limitations, this work constitutes a valuable contribution to gravimetric knowledge of Antarctica, and, once elevation data are available, will provide basic data for various for various geodetic and geophysical studies of the crust and the underlying rock surface.

No 3—Seismic Soundings Across Antarctica

This report is in four parts and covers (1) a description of the seismic equipment and field procedures used, (2) reflection measurements on the Antarctic ice cap, (3) refraction measurements at Southice, and (4) reflection measurements on the Filchner ice shelf at Shackleton.

A standard 12-channel Electro-Technical Laboratories M4a reflection apparatus was used with single and mixed recording. The geophones were peaked at 20 c/s and, depending upon whether reflection or refraction measurements were being made, were used in groups of 4 or 16, and at 10-meter intervals on 390-meter cables. On reflection work 3-channel recording was obtained with four different filter settings. The shot hole was usually a 12-meter hole drilled with a hand augur; the hole was also used for temperature studies prior to shooting. The author feels that deeper shot holes and deeply buried geophones would have given better results because of the high surface-noise level encountered. In all, 35 seismic determinations of ice thickness were made on the polar plateau; these indicated depths to the underlying rock ranging from 320 meters to 2820 meters. The standard error for the measurements is given as ranging from 32 meters at a depth of 500 meters, to 44 meters at a depth of 3000 meters. However, measurements of ice thickness made by other investigators at Pratt's South Pole site suggest that the errors may be appreciably larger. In gross form, however, Pratt's profile gives a comprehensive picture of the variations in ice thickness across Antarctica. Although exact surface elevations for this traverse are still to be determined, the altimeter observations indicated that the rock surface is above sea level everywhere except at two localities near Southice, where deep valleys appeared to be incised about 2000 meters below the general level of the rock surface. Similar variations in the rock surface have been found also in Western Antarctica, and can be regarded as normal.

The refraction program at Southice was carried out primarily to determine the velocity of sound waves in ice. The results indicate an exponential increase in apparent velocity of the waves with depth of penetration, the increase ranging from 0.5 km/sec at the surface to about 3.9 km/sec at a depth of 90 meters, as recorded at a distance of 500 meters from the shot point. A maximum velocity of 3.94 km/sec, beyond which the velocity was constant, was reached at a range of 800 meters from the shot point.

Six determinations of ice thickness were made on the floating Filchner ice shelf. These measurements indicate that the ice varies in thickness from about 300 meters at the outer edge to about 500 meters at the innermost site occupied (about

1600 meters from the seaward edge). The water column beneath the ice was found to be at a depth of about 800 meters, which places the sea floor here on the continental shelf at a depth of about 1200 meters (approximately 600 fms). The writer gives a very full treatment of the mathematical considerations used in calculating the depths cited, points out weaknesses in the arguments used, and gives the reasons why he followed certain courses that he feels might be questioned by others. This well-written report is valuable for anyone making similar measurements on ice. It is not only quite factual and informative but also entertaining.

No. 4—Tides at Shackleton, Weddell Sea

This report deals with tidal variations on the floating Filchner Ice Shelf, as noted with a Worden gravity meter. The nearest determinable land, a nunatak, was 25 miles distant. The floating ice layer, about 400 meters thick, was underlain by approximately 800 meters of water.

Observations were made automatically, and on an hourly basis, by means of a time lapse camera. The instrument was housed in an excavated ice cavern 18 feet below the surface near the Shackleton base camp. The gravity meter used was the same as that used on the trek across Antarctica; it had an ocular scale reading sensitivity of approximately 0.05 mgals, as measured from the recording film. In order to smooth out 'noise,' each reading consisted of a 10-minute exposure, and the mean position of the resulting blurred image was used to determine the gravity change relative to the fiducial reading position on the ocular scale. Observations covered the period from August 8 to October 3, 1957. The author discusses the operational problems of exposure, servicing the meter, maintaining level, and the apparent effect of the operator's presence on the readings. He also takes up the problems of calibrating the ocular scale and of the mathematical methods of filtering in order to remove instrumental drift and to obtain true values of gravity change for tidal analysis. A harmonic analysis of the corrected values is made, and it is shown that, in addition to true tidal variations, spurious tides are also present, which can be related to diurnal variations in the voltage supplied to the gravimeter lamp and the periodic reloading of the camera. These spurious tides are evaluated and removed, and the true tide is analyzed as to its harmonic constants by different standard methods currently employed. This is an interesting study, and it would be of interest to compare these results with those obtained at the Ellsworth Station, also located on the Filchner Ice Shelf but at a considerably greater distance from any known land. Such a comparison might give data for evaluating the damping induced by the fact that the ice sheet (over 200 inches thick) is not free floating but is grounded at its inner margin. The ideal experiment, of course, would be to make a series of simultaneous tidal observations at different distances across the ice shelf.

G. P. Woollard

Addendum by Author (added in proof) Since the completion of this review seismic results for additional measurements at the South Pole and for a crossing of Pratts line in Victoria Land have become available. These results show that the rock surface is approximately at sea level, whereas Pratt's values indicate the rock surface is from 600 to 1000 meters above sea level.

G. P. W.

FREDERICK I. ORDWAY, III, *Advances in Space Science, Volume 2,* Academic Press, Inc., New York, 450 pp., 1960, $13.00.

The wide scope of space science is illustrated best by the subjects of the six review chapters in this book. They range from space physics, to satellite tracking, materials, electrical propulsion systems, and attitude control. The first chapter by Charles P. Sonett on 'Experimental Physics Using Space Vehicles' is unusually comprehensive (115 pages) and covers the subject matter as well as the techniques in a very authoritative and detailed way. There is much important information on instrumentation and detectors for various types of radiations, as well as on the problems of telemetering, and on construction of instruments. In all cases, the background is well described; an example is the operation of various types of magnetometers, and the discussion of precision and errors associated with them. One suspects that this chapter will prove most useful to any prospective satellite experimenter since it carries the process from design of experiment to environmental testing of the equipment.

The next chapter by Karl G. Henize deals with 'Tracking Artificial Satellites and Space Vehicles,' and discusses both radio and optical tracking, with strong emphasis on optical photographic systems, such as have been used at the Smithsonian Astrophysical Observatory.

Frederick L. Bagby of the Battelle Institute, describes 'Materials in Space,' a subject of greater interest to engineers.

The next two chapters deal with electric propulsion devices. Morton Camac of AVCO describes 'Plasma Propulsion Devices,' including arc-heated jets, magnetohydrodynamic accelerators, and similar devices. The underlying theory is briefly described and its realization to propulsion hardware is indicated.

Ernst Stuhlinger and Robert N. Seitz, of the Marshall Space Fight Center, discuss 'Electrostatic Propulsion Systems for Space Vehicles' dealing, of course, with ion propulsion. This subject is developed in great detail, including the optimization of an ion propulsion system for various types of missions.

The final chapter by Robert E. Roberson, of the Systems Corporation of America, is concerned with 'Attitude Control of Satellites and Space Vehicles.' The treatment deals mainly with the dynamics of the problem, including an analysis of the torques that are likely to act on a body in space. This is followed by a brief discussion of attitude sensing, mainly by dynamical devices, although various physical effects are also briefly mentioned. Finally, the attitude control problem is described.

The selection of topics in this volume is certainly very good. It strikes a nice balance by presenting the state of the art and incipient developments, rather than by veering off too much into the future.

S. F. Singer

S. Basu, K. R. Ramanathan, P. R. Pisharoty, U. K. Bose (Editorial Committee), Symposium on Monsoons of the World; Hind Union Press, New Delhi, 270 pp., 1960, Rs. 12.00.

In February 1958 the International Union of Geodesy and Geophysics and its International Association on Meteorology and Atmospheric Physics joined the World Meteorological Organization in sponsoring the symposium on Monsoons of the World. The present volume presents the text of 25 of the papers read on that occasion, and 9 in abstract form. These contributions deal with the climatology of monsoons, the relation of monsoons to the general circulation, the dynamics of monsoons, synoptic features of monsoons, rain and clouds associated with monsoons, the variability of monsoons, and long-range forecasting of monsoon character. It is obviously difficult to review these contributions in detail but a few general remarks may convey some impressions.

Indian authors predominate among the contributors and over three quarters of the contents deals with Indian monsoons, in spite of the rather ambitious title. Also, the discussion of the summer monsoon almost completely relegates the winter monsoon into the background. All this is understandable if one remembers that the summer rains which accompany the SW-monsoon are the lifeblood of Indian agriculture.

A great deal of valuable information has been brought together, including seasonal charts at various levels. New aerological material has made more complete three dimensional analysis possible than heretofore. Even so, writer after writer feels that many more observations by rawinsondes are still needed to learn about many of the remaining mysteries of the monsoons. This is particularly essential in order to test the hypothesis of Flohn stating 'that the seasonal warming of the elevated heat source of the Tibetan Plateau and the following reversal of the meridional temperature and pressure gradients south of lat. 35°N produces the far-reaching switch of the planetary wind belts over Southern and Eastern Asia, together with the "burst of the monsoon" over the Indian subcontinent.' Koteswaram also stresses the importance of the Tibetan Plateau on the general circulation in the tropics. However, there are mild dissents from this thesis. In fact, one might well heed the admonition of Scherhag in his recent book (Einführung in die Klimatologie, Braunschweig 1960) to await adequate evidence before going too far in accepting new models. In particular, there are ample indications that one has to consider conditions on *both* hemispheres jointly before one can arrive at the proper conclusions about monsoons.

Much of the statistical information on cyclones in the Bay of Bengal and the Arabian Sea, as well as various analyses of rainfall figures presented in this volume are valuable summarizations of data which are now in scattered references. It is also interesting to note that monsoonal rainfalls show irregular fluctuations centered around a 7-day pulsation. A continuation of Sir Gilbert Walker's attempts to predict monsoonal intensities by regression methods based on atmospheric teleconnections with suitable lags, with a few recent refinements, shows still moderate success.

A few pages at the end of the volume are devoted to some brief discussions.

One misses adequate discussions of the monsoon conditions on the Asiatic Pacific Coast and of the monsoonal tendencies in the Americas. One has also to be satisfied with two short papers on Africa, with an additional note on Madagascar, and only one on Australia.

On the whole this volume suffers from an endemic ailment of symposia publications. The level of presentations is very uneven. The manuscripts are written beforehand. There is little, if any, opportunity for thorough discussion at the time of presentation, and probably equally little to revise the manuscripts later. Conflicting opinions are neither resolved nor are the issues or remaining questions sufficiently clarified. Would it not be better, perhaps, to narrow the scope of these meetings, give the participants the draft papers in advance, use the meeting to discuss them thoroughly, and have the results summarized for publication by a few knowledgeable participants in a fair but critical manner?

However, this volume is a 'must' reading for all meteorologists interested in tropical problems and in the general circulation. They can then decide for themselves what progress we have made since the day of Halley, nearly three centuries ago.

H. E. Landsberg

Glenn T. Trewartha, *The Earth's Problem Climates*, University of Wisconsin Press, Madison, 1961, vi + 334 pp., 1961, $7.50.

The study of the climates of the Earth reveals a complex fabric of variety. Many attempts have been made to discover the system in nature's weaving. Ideal schemes are often presented in introductory courses in climatology, but any detailed analysis shows that exceptions to such schemes are common. These exceptions are what Professor Trewartha calls 'Problem Climates.'

The six parts of the book cover the major geographical areas: Latin America, Australia-New Zealand-Equatorial Pacific, Africa, Southern and Eastern Asia, Europe and the Mediterranean Borderlands, Anglo-America. The author uses, by and large, the Koeppen classification as the major guide to the problem areas. Thornthwaite's scheme is resorted to for an occasional aid. Some of the 'anomalies' show up in the temperature data but by far the larger share is cited in terms of precipitation. What one ought to take as 'normal' remains mercifully vague.

The importance of rainfall in human affairs makes it uniquely appropriate as a target for investigations. Areas with rainfall problems, especially temporal deficiencies, usually are also areas of economic and, not infrequently, of political problems. In many regions of the world the meteorological observations are unsatisfactory for a precise spatial and temporal analysis of the climatological facts. Attempted explanations suffer even more, especially in the absence of upper air and marine data. In many of the regions discussed by the author, principally Latin America and Africa, most of the reasoning has to deal with orographic controls, ocean currents, and the basic flow patterns of the general circulation. The pertinent literature and opinions obtained from local meteorological sources are cited. As the discussion proceeds to the regions of Western Europe, East Asia, and North America the details of three dimensional synoptic patterns, large-scale flow, jet streams and air mass preponderances are added to the explanatory efforts.

The great difficulties in our present state of knowledge are the many apparent 'hen and egg' problems of climatogenesis. Wind-driven ocean currents and upwelling with their effects on coastal conditions are a pertinent example. Another difficulty is inherent in the classical method of summarization of climatic data. I agree emphatically that the 'use of monthly averages is not a completely satisfactory way of analyzing the geography of weather types.'

In reading one becomes acutely aware of the terminological confusion that exists in climatology. For example, the term 'monsoon' is applied to genetically quite different things. One also wonders why so many of the tropical and subtropical climates are classed as problems. Is this caused by our lack of understanding as to what might be 'normal' there? In general, can individual peculiarities of a temporal nature be explained on a localized basis or must we search for a hemispheric—or even global—basis for the causes?

Professor Trewartha's work is a feat of diligent scholarship. It certainly is a challenge for more research into the obscure causality of the many facts he cites. The student, however, is likely to find this book a bit tough going. In fact, I would suspect that many will draw the conclusion that climatology is made up of 'exceptions.' Perhaps the arrangement by geographical regions places the emphasis on patchiness. Had all desert regions or all coastal ranges been placed in juxtaposition, a more coherent picture might have emerged.

The book is well illustrated, handsomely produced, and carefully edited. It would have been easier for the reader had the literature citations been presented in the conventional form and separated from notes. At least, second citations of the same literature reference should indicate where the full reference can be found. A future edition might also be expanded to include the very interesting problem climates of the USSR, the unique problem of Greenland, and the intriguing patterns of Hawaii.

H. E. Landsberg

Robert M. Garrels, *Mineral Equilibria*, Harper & Brothers, New York, xvi + 254 pp., numerous tables, 88 figures, 1960, $6.00.

For more than fifty years the dominant and successful physico-chemical attack on geologic problems has been the application of Gibbs' phase rule to the study of multicomponent systems. Within the last decade, there has been a resurgence in the application of other physicochemical principles to the study of the Earth. The intense concern about (1) our dwindling ore deposits, (2) our water resources and (3) the study of the oceans, has revived research in the study of the liquid state, viz. liquids and solutions. This book represents the application of two physicochemical concepts—pH and Eh—to the portrayal of stability relationships in aqueous systems.

Professor Garrels has presented an excellent treatment of the subject. It reads well, is understandable, is imaginative and is thought provoking. Anyone interested in problems involving aqueous solutions in chemical geology will find this book necessary reading.

The first four chapters deal with a review of some principles of physical chemistry and an introduction to the approach to the problem. The preparation of the partial pressure diagrams and the Eh–pH diagrams is treated in detail. Basic to these diagrams is an understanding of the stability of water as a function of the partial pressures of oxygen and hydrogen in equilibrium with water. Partial pressure diagrams are developed for water; iron oxides; $Fe–O_2–CO_2$; $Cu–O_2–CO_2$; $Fe–O_2–S_2$; $Cu–O_2–S_2$; $Fe–O_2–CO_2–S_2$; $Cu–O_2–CO_2–S_2$; and the superposed diagrams $Fe–Mn–O_2–S_2$; $Fe–Mn–O_2–CO_2$; $Fe–Cu–O_2–S_2$.

Eh–pH diagrams are given for the stability of water, the iron oxides, and the iron hydroxides. Next, the effect of carbon dioxide and sulphur are separately investigated for the relationships of iron–water–oxygen systems, and then the combined effects are presented together. Based on limited thermodynamic data, an attempt is made to explore the relations involving a hypothetical iron silicate.

Eh–pH diagrams are constructed for lead, copper, manganese, nickel, cobalt, tungsten, uranium, vanadium, and gold. The last chapter deals with geologic applications of Eh–pH diagrams.

Professor Garrels is the leading exponent of the use of Eh–pH diagrams in America. His book will do much to spread this technique in geochemical studies.

George T. Faust

Samuel S. Goldich, and others, *Precambrian Geology and Geochronology of Minnesota,* Minnesota Geological Survey Bulletin 41, University of Minnesota Press, Minneapolis, 193 pp., 1961. $4.00.

The title of this publication suggests a subject largely of local significance, but the book deals actually with data and interpretations of far wider scope. Indeed, it is of value to all geologists who are concerned with the chronology of Precambrian rocks, for it is based primarily on radioactivity age determinations, which, as the authors state ". . . affords the best if not the only possibility for correlating Precambrian rocks." This facet of the subject is not evident in the title.

Minnesota and adjacent areas have long comprised a classic scene for work on the Precambrian. It was here that detailed studies under modern concepts of stratigraphy and structure were made by Van Hise, Leith, Lawson, and numerous other eminent geologists of the 'Lake Superior school,' as well as by their Canadian confreres—Coleman and others—of equal notability. Many, indeed, are the students of metamorphic geology who have been brought up under the instruction and guidance of these masters, devoted teachers who laid the foundations for others to build on. What though the rising structure has at times seemed strangely incongruous and unintegrated in some of its parts! The complexity of the structural and stratigraphic problems inherent in such ancient terranes has demanded more than the means formerly at hand. The confusion is not in any sense attributable to failure by those masters; they blazed many enduring, though in places, somewhat tortuous, paths in the wilderness. But some things could not be soundly resolved. Chief among these was the matter of stratigraphic correlation with other, widely separated, areas as well as within the province. The development of methods of age determination through radioactivity has brought a soundly hopeful approach to the problems of Precambrian chronology, and hence to stratigraphic succession. It is quite fitting that the laying of a foundation for general Precambrian correlation through these methods should have been carried on so constructively within this classic area.

The authors wisely decided to retain geologic names used previously in the Lake Superior region "until more definitive data" are available. An interesting comparison of their stratigraphic column with that of Grout and others (1951) is given in two tables. They retain the three-fold main divisions of Precambrian time but replace the terms 'Earlier, Medial, and Later' by the somewhat more definitive Early, Middle, and Late. The term *Huronian* still appears in their table, as Middle Pre-Cambrian, pending further resolution of the problem. The three main divisions are separated at 2.5 billion years (*Algoman* orogeny rather than *Laurentian*), and 1.7 billion years (*Penokean* orogeny, earlier assigned to the late Keeweenawan). *Penokean* has been dated much earlier than formerly, and *Algoman* has received 'billing' superior to *Laurentian*. This accords with the fact that a compilation of radioactivity ages from different parts of the world shows a marked frequency of dates at 2.6–2.5 billion years, 1.8–1.6 billion years, and 1.1–0.9 billion years, and that "it is unlikely that this pattern is wholly the result of chance"; this is believed to be indicative that geosynclinal accumulations of sediments and the succeeding orogenies cannot be explained entirely by crustal forces, but must be related to subcrustal forces.

The object of this brief review is to emphasize the importance and significance of the publication. Detailed review and analysis would be quite outside the scope of either the reviewer's direct experience in such methods or of the allotted space. One must, however, be impressed by the amount of new radioactive-age data, and by the extent to which these data have been rationalized within the basic regional facts.

As the authors state the main objective was "to date . . . as many of the intrusive rock types as possible and to build the framework of a time scale within which the formations and events as interpreted from geologic studies can be fitted." After outlining and discussing (in 28 pages) the potassium-argon and rubidium-strontium methods, the authors proceed with a description (114 pages) of their studies in three major areas—northern, east-central, and south-western Minnesota. The book concludes with a chapter of 19 pages on 'Development of a Precambrian classification.' No student of Precambrian geology can afford to be without this report.

The reviewer cannot forbear, in closing, to point out that the authors recognize as paragneiss, some rocks that were regarded as intrusives by Grout and others. The trouble with the term 'granitization' (it does not appear in this work—perhaps it is a 'dirty' word!) is that it tends to conjure quite different pictures of genesis, according to one's peculiar predilections. Nevertheless, it connotes a broad metamorphic principle, whether or not it be masked by other terms, such as the much-abused 'migmatite' or the decidedly less vague 'metasomatism.' The reviewer is not too fond of the term 'grantization' anyway, though he remains complacent about the whole concept implied by its use. Insofar as radioactive-age determinations are involved, however, the authors were concerned with rocks of truly igneous origin, and have been content to recognize the probable sedimentary origin of some of the problematic granitic gneisses, whatever the process of metamorphism.

L. W. Currier

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The production of the English edition has been undertaken with the aid of a grant from the National Science Foundation starting with the series for 1957. Orders for sets for 1957 through 1961 ($25.00 for each set of twelve numbers) should be sent to the American Geophysical Union. Individual numbers are available for $5.00 each.

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Note—Starting with the December 1960 issue of the *Transactions*, the contents of the English translation of *Geodesy and Cartography* will appear in successive issues.

Publication of an English edition of this leading monthly journal of Geodesy and Cartography in the USSR has been undertaken with the aid of a grant from the National Science Foundation, starting with Number 1 (January) of the 1959 volume. A volume set of 12 numbers is priced at $20.00, and orders should be sent to the American Geophysical Union. Two-issue copies available at $7.50, (nos. 1 and 2 bound together, etc.). Subscriptions are now being received for the 1960 volume.

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Notes and Personalia

Notes

• Corrigendum—J. N. Carruthers has drawn attention to the fact that our reporter for the July 29 session of the International Association of Oceanography at the 12th General Assembly, International Union of Geodesy and Geophysics, Helsinki, Finland (page 632, December 1960 issue of *Transactions*) was at fault in some of his remarks about certain features of the leaning tube current indicator described by Carruthers. In the mimeographed synopsis of his paper, which was passed out at the Helsinki meeting, Carruthers described how he had assured himself by practical test that the solidifying jelly gives a completely acceptable indication of the mean current flow even when rocked back and forth to simulate wave action. There was no question of seiche motions of the setting jelly in such a narrow bottle falsifying the results.

• Corrigendum—In the March 1961 issue of *Transactions*, page 73, the first sentence should read as follows: 'Two reports for the fiscal year ending June 30, 1960 have been prepared, one on the previous cash basis, as in former years. . . .'

• Corrigendum—Owing to a late adjustment in make-up of the December 1960 issue of IGY Bulletin, the article *Geology of the Windmill Islands, Antarctica* indicated in the table of contents of December *Transactions* as appearing on page 722 was displaced by the article *International Geophysical Calendar for 1961*. The displaced article appears in March 1961 *Transactions*, pages 103–106.

• **Competition Announced for 1962–63 Fulbright Foreign Lecturing and Research Awards**—The Board of Foreign Scholarships and the Department of State have announced that competitive applications will be received for 1962–63 awards under the Fulbright Act, for university lecturing and advanced research in seventeen European countries, four Near-East countries, China (Taiwan), Japan, Korea, and United Kingdom colonial areas in Africa, Hong Kong, Malta, Singapore, and the West Indies. For lecturing, at least one year of college or university teaching, and for the research projects either a doctoral degree or recognized professional standing, are required. Only citizens of the United States are eligible. In some cases a knowledge of the language of the host country is required. Awards are tenable in one country, and usually for an academic year.

Awards provide roundtrip travel for the grantee and for one dependent of lecturer, for certain countries of Asia, Africa, and Latin America. Maintenance allowance covers ordinary living costs of grantee and family while in foreign residence. Further information is obtainable from the Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Avenue, Washington 25, D. C. The closing date of the competition is October 1, 1961.

A similar competition for 1962–63 that embraced Latin America, South and Southeast Asia, and the Pacific area closed on May 1, 1961.

• **NSF Postdoctoral Fellowships**—The National Science Foundation expects to reopen the Postdoctoral Fellowship Program in July, for awards to be made in October, 1961. Under this program Fellows receive an annual stipend of $4500, an allowance for dependents, and aid in defraying the cost of travel. The awards are to enable study or research at 35 institutions in the United States and in 50 foreign countries. Selection of awardees is made by the NSF from applications evaluated by a panel appointed by the National Academy of Sciences-National Research Council. Applications giving appropriate evidence of scientific competence, including academic records and letters of recommendation, are received by the National Science Foundation, 1951 Constitution Ave., N.W., Washington 25, D. C.

• **Advanced Course in Water Pollution; at Munich**—The Bayerische Biologische Veranstalt, of Munich, Germany, announces an advanced course in *Water pollution with oil, tar products, and detergents in relation to sanitation and fishery biology* to be given in Munich, October 2–6, 1961. The course is to be under the supervision of Prof. H. Liebmann. The fee is DM70, including travel expenses for an excursion. Final reservations will be announced by September 25. Address inquiries to Prof. H. Liebmann, Bayer Biologische Versuchanstalt, Veterinärstrasse 13, Munich, Germany; fee to be made out to Postscheckamt München Account No. 66550.

• **Bureau of Standards Offers Courses in Radio Propagation**—A three-week course in *Radio Propagation* is being offered by the National Bureau of Standards at its Boulder, Colorado, Laboratory. The course consists of two parts: *Tropospheric Propagation*, July 31 to August 4, 1961, and *Ionospheric Propagation*, August 7 to August 18. Registrations will be limited. A bachelor's degree in Electrical Engineering, or Physics, or other suitable academic or practical experience is prerequisite. Tuition is $100 for Tropospheric Propagation, and $200 for Ionospheric Propagation. Details may be obtained from Edmund H. Brown, Educational Director, Boulder Laboratories, National Bureau of Standards, Boulder, Colorado.

• **NSF Grants for Summer Conferences for College Teachers of Science, Mathematics, and Engineering**—The National Science Foundation has granted approximately $366,000 to 23 collegiate institutions in 13 States and the District of Columbia in support of Summer Conferences for College Teachers of Science, Mathematics, and Engineering. More than 650 participants will receive stipends up to $15 a day, plus travel allowances. Neither tuitions nor fees are charged for the Conferences, which last four weeks or less. The Conferences are designed to strengthen mastery of newer developments in the fields and to increase effectiveness in teaching. Participants are chosen by the individual Conferences, and not by NSF. A list of the institutions offering these Conferences may be obtained from the National Science Foundation, 1951 Constitution Ave., N.W., Washington 25, D. C.

• **Undergraduate Research Participation Program of NSF**—The National Science Foundation has made 357 grants, totalling $3.2 million, through its Undergraduate Research Participation Program, now in its third year, to help build the interest of superior students in research. The students will work with scientists in more than 250 colleges and universities, beginning with the coming summer. Together with 165 awards made in 1960, about 2400 undergraduates will participate during the 1961 academic year. Some of the grants are for two years. The students receive nominal stipends, and are chosen by the institution holding the program.

• **Seismograph Placed on Ocean Floor Records Earthquake**—The first recording of an earthquake by a seismograph placed on the ocean floor has been reported by Maurice Ewing, Director of Lamont Geological Observatory, who said that the new technique may give scientists a thousand times more information about the Earth's structure than has been available heretofore. The 'quake was recorded at a depth of approximately three miles below the surface of the Atlantic Ocean, at a point about 120 miles southwest of Bermuda. The seismometer, amplifier, FM transmitter, and batteries were enclosed in an underwater device 14 feet long, with a nose cone and a spike at one end, and tail fins on the other. The signals were transmitted to the surface by acoustic telemetering. The earthquake recorded was of 5 or 6 magnitude (Richter scale) and its epicenter was near Colon, Panama.

It is said that shocks from nuclear explosions as well as from very slight earthquakes may be detected by such units 'with better sensitivity than ever before' because there is far less background noise on the ocean floor than on land.

- NEW MEASUREMENT SCIENCE CENTER AT THE GEORGE WASHINGTON UNIVERSITY—The Nation's first measurement science center opened at The George Washington University, Washington, D. C., with classes that began on February 6. About 100, chiefly graduate students from government and industry, enrolled in the eight courses offered in the field of *metrology,* the study of highly precise measurement. The need for precision measurement has far outdistanced the instrumentation and technical skills now available. The National Bureau of Standards—the agency officially responsible for metrology—and the School of Engineering of the University are thus planning to meet this need through a curriculum that can lead to both undergraduate and graduate University degrees in engineering.

- NEW GRADUATE SCHOOL OF SCIENCE AND ENGINEERING AT SAN DIEGO CALIFORNIA—The University of California opened the doors of its new School of Science and Engineering at San Diego in September. The School is designed to provide graduate instruction and basic research in the sciences and engineering. Departments of Physics, Chemistry and Earth Sciences are operating currently, but curricular expansion into other fields is planned. The School is the first step in the establishment of a large general campus of the University in the San Diego area.

Roger Revelle has been designated Dean of the new School; he will, however, retain his position as Director of the Scripps Institution of Oceanography, an academic and research unit of the University.

- FEDERAL FUNDS FOR SCIENTIFIC RESEARCH AND DEVELOPMENT IN 1961—The National Science Foundation has announced that the Federal Government will obligate an estimated $9.1 billion during 1961 for the support of scientific research and development. Of this, about $850 million is assigned to basic research. The Department of Defense, the AEC, and the NASA are expected to administer about $7.6 billion.

- WORLD'S LARGEST SOLAR TELESCOPE UNDER CONSTRUCTION—Work is progressing on the construction of the world's largest solar telescope at the Kitt Peak National Observatory atop Kitt Peak, near Tuscon, Arizona. An 80-inch heliostat mirror at a height of 110 feet above the ground will track the Sun and reflect a 34-inch image into an underground observing room, where it may be photographed or directed to spectroscopes. The instrument is being built by the Association of Universities for Research in Astronomy, for the National Science Foundation, which has allotted $4 million to the project. It is expected that the instrument will be completed in 1962.

- BALLOON-BORNE TELESCOPE FOR PHOTOGRAPHING PLANETS AND NEBULAE—According to a joint announcement by the National Science Foundation, the Office of Naval Research, and Princeton University, Stratosphere II—a balloon-borne 36-inch telescope system weighing more than two tons—will permit picture-taking with a resolution three to five times greater than pictures taken from the ground. The balloon will rise to 80,000 feet, above nearly all the turbulence and dust of the atmosphere that distort and obscure ground-based observations. The program is sponsored by NSF, ONR, and NASA, and is under the direction of Martin Schwarzchild, Astronomer at Princeton University. The first full-scale launching with the telescope is planned for the fall of 1961.

- TEST DRILLING FOR PROJECT MOHOLE COMPLETED—Preliminary experimental drilling as part of Project Mohole is underway at a site in the Guadalupe Island area, off the western coast of Mexico. A 'dress rehearsal' on the drilling experiment was completed in March, in 3140 feet of water near La Jolla, California; this operation yielded the deepest cores of the ocean bottom that had ever been obtained in deep water.

At the Guadalupe Island area a second hole was started on March 31, in 11,700 feet of water; it passed through 560 feet of gray-green clay of Miocene age into a basalt layer, which corresponds to the so-called 'second layer' predicted previously by seismic tests. The test drilling was completed in early April.

The test program was carried out by the AMSOC Committee of the National Academy of Sciences-National Research Council, and was supported by the National Science Foundation, under a $735,800 contract with the Global Marine Exploration Company of Los Angeles. This Company's drilling ship *Cuss I* has been modified to work in water too deep for the usual anchoring. By means of sonar the ship's position will be 'sensed' relative to a ring of six buoys that will, themselves, be anchored to the bottom by a taut wire to hold them 200 feet below the surface of the water; each of the buoys will be about 1000 feet apart from each other and from the ship. Using the sonar information, the pilot will be able to reposition and keep the ship over the drilling hole by simultaneously controlling four outboard motors.

- RADIO SIGNALS AID STUDY OF VENUS—Successful detection of radio signals that are bounced off Venus, without elaborate processing and analysis, has been announced from the Jet Propulsion

Laboratory, operated for The National Aeronautics and Space Administration (NASA) by the California Institute of Technology. The first successful transmission and reception took 6½ minutes to make the more than 70 million miles of round trip. This was part of a two-month experimental program, the objectives of which were (1) to determine if Venus spins on its axis, and, if so, the speed of the rotation, (2) to determine the orientation of its axis, (3) to investigate the reflective nature of the surface of Venus, and (4) to further define the astronomical unit of distance, approximately 93 million miles (the mean distance from the Earth to the Sun), which has so far been defined only to within 10,000 miles.

• Coesite Formed by Atomic Explosion—Coesite, the dense, highly stable form of silica first produced in the laboratory, but lately discovered in meteorite craters in Arizona, Germany, and Arabia, has been identified for the first time in material shocked by an atomic explosion. The identification was made by mineralogists of the U. S. Geological Survey working on samples of rock debris obtained from the Teapot E Crater, formed at the Nevada Test Site in 1955, when a 1.2 kiloton atomic device was detonated 67 feet below the surface of the ground. The structure of this crater—300 feet in diameter and originally 100 feet deep—is very similar to that of Meteor Crater, Arizona, from which specimens were obtained in which coesite has recently been identified.

• Dispersal of Atomic Waste in Oceans Being Studied—The Atomic Energy Commission has contracted with the Lamont Geological Observatory to study the movements of ocean waters in relation to disposal of atomic wastes. The research starts this summer in the North Atlantic, near Bermuda; it is expected that eventually the project will be extended to cover other major ocean areas. Initial work will be carried on to a depth of 655 feet, and later to depths of 18,000 feet. Maurice Ewing, Director of the Observatory, pointed out that, until the quantitative factors of mixing, diffusion, and circulation rates in specific areas are known, rational controls over ocean-borne radioactivity will not be possible.

• Lightning Research at University of Arizona—A project to photograph lightning strokes, started in 1960 at the University of Arizona's Institute of Atmospheric Physics, is being continued under a supporting grant of $15,000 awarded by the Office of Naval Research. Leon E. Salanave, Research Associate, is in charge. The major objective is to obtain a well-focussed photograph of a single stroke of lightning to show the many lines of the spectrum present.

• New Value of Carbon-14 Half-Life—The National Bureau of Standards has announced determination of a more accurate value for carbon-14 half-life. The new value of 5760 years, as compared with the previously accepted value of 5568 years is in fairly good agreement with the value of 5900 ± 250 years obtained by the Bureau in 1953.

• Role of Satellites in Weather Forecasting—A statement issued by the American Meteorological Society emphasizes that data obtained by means of satellites will lead to better forecasting, especially for hurricanes and severe coastal storms, for which timely weather observations are commonly not available, or are very incomplete, from ships and aircraft. As satellite observations become an integrated part of the data available at forecasting centers the quality of predictions will increase. Incorporation of such observations into fundamental research on the mechanics of the atmosphere will improve understanding of the nature of weather processes and bring about additional benefits for the welfare of mankind.

• Continuous Televised Weather Briefings Available at Idlewild Airport—The Weather Bureau is now operating a closed television circuit in the Weather Bureau Briefing Office at the Idlewild International Airport, to aid pilots, crews, and forecasters in obtaining weather briefings for a wide range of routes and the higher altitudes. The continuous discussion and display of charts are changed at least every six hours, and more often if needed because of markedly changing conditions. The charts cover anticipated wind and weather conditions for the major international routes at levels up to approximately 45,000 feet. Similar systems are being installed at Miami, Florida, and San Juan, Porto Rico.

• U. S. Corps of Engineers Combines Two Cold Regions Units—The Snow, Ice, and Permafrost Research Establishment (SIPRE), Wilmette, Illinois, has been redesignated *U. S. Army Cold Regions Research and Engineering Laboratory* (CRREL). The Arctic Construction and Frost Effects Laboratory (ACFEL), Waltham, Massachusetts, has been placed under the command jurisdiction of the Director of CRREL, Colonel W. L. Nungesser. It is expected that later in the year the two agencies will be merged completely and moved into new facilities now under construction in Hanover, New Hampshire. Land for the new laboratory was donated by Dartmouth College, which has long been directly interested in polar studies. The new facilities will provide 22 cold rooms, and laboratories for research in soils, physics, chemistry, electronics, and aerial photography. It will also have a highly specialized library, and digital and analog computers.

• Lamont Geological Observatory Has New Building Program—A new Geophysics building and a second Oceanography building, both to be used principally for research supported by the Office of Naval Research, will be added at the Lamont Geological Observatory establishment, Palisades, N. Y. at a total cost of approximately $880,000. The new construction will provide 46,400 square feet of floor space, and will greatly increase facilities for both research and graduate instruction in geophysics, geochemistry, marine geology and biology, and the broad application of scientific and engineering methods to the study of the Earth and the planets.

- **National Oceanographic Data Center Dedicated**—The home of the new National Oceanographic Data Center was formally dedicated on January 16, 1961. The Center was officially established on November 1, 1960, and assigned the third floor of Building 160 of the Naval Weapons Plant, Washington, D. C., which was renovated for the purpose. The Center is sponsored and financed, and its policies determined, jointly by the Department of the Navy, the U. S. Coast and Geodetic Survey, the Bureau of Commercial Fisheries of the Department of the Interior, the National Science Foundation, and the Atomic Energy Commission. The Center is administered by the U. S. Navy Hydrographic Office; Harold W. Dubach is the Acting Director. Members of the Interagency Advisory Board are: Howard H. Eckles, Bureau of Commercial Fisheries; John Lyman, National Science Foundation; Arthur E. Maxwell, Office of Naval Research; Boyd E. Olson, U. S. Navy Hydrographic Office; Donald W. Pritchard, of The Johns Hopkins University, and Vice President, Section of Oceanography, AGU; Milner B. Schaeffer, Inter-American Tropical Tuna Commission; Robert W. Schloemer, U. S. Weather Bureau; Vincent Schultz, Atomic Energy Commission; Harris B. Stewart, Jr., Coast and Geodetic Survey.

The Center was established because of a need by government agencies, as well as by other public and private interests, for the establishment of an organization for acquiring, compiling, processing, and preserving oceanographic data for ready retrieval.

- **Wichita Mountains Seismological Observatory Publishes New Bulletin Series**—Commencing with the January 1961 issue a new monthly bulletin series is being published by the Wichita Mountains Seismological Observatory, chiefly for the reporting of data on earthquakes. The Observatory is situated about 15 miles northwest of Lawton, Oklahoma. It is operated by the Geotechnical Corporation of Garland, Texas, under the technical supervision of the Air Force Technical Applications Center, and as part of Project Vela-Uniform of the Advanced Research Projects Agency. For inquiries relating to the bulletin and the Observatory, the mailing address is: The Geotechnical Corporation, P. O. Box 28277, Dallas 28, Texas.

- **Scandinavian Research Guide Published**—The Scandinavian Council for Applied Research (SCAR) has published a two-volume guide of research institutions, societies, libraries, and publications of the five Scandinavian countries. The work is in English, and comprises 1173 pages, including indexes. The Office of Documentation of the National Academy of Sciences-National Research Council has acquired copies of the guide, with the financial aid of the National Science Foundation, for the purpose of making this comprehensive work available to scientists in the United States. The work embraces the physical sciences and technologies, and is considered to be 'a remarkable step forward in international scientific cooperation'; it is hoped that the work will stimulate production of similar volumes by scientific groups in other countries. The price of the two volumes is $10.00.

- **New Map of Aletsch Glacier**—A new contour map of the Aletsch glacier as of September 1957, on 1:10,000 scale, contour interval 10m, is being published by the Topographical Survey of Switzerland. Availability of Sheet No. 3, the first of four, has been announced; this embraces the main tongue of the glacier from Märjelen Lake to the snout, plus adjoining watershed within the drainage basin. This map series, a contribution to the International Geophysical Year, will be of special importance to glacialists, as it will be the most accurate and detailed map of a major glacier and its complete drainage basin. The Great Aletsch Glacier is the longest and largest glacier of the Alps.

- **Atlas of Moon's Hidden Side**—The first atlas of the far side of the Moon, released by the USSR Academy of Sciences in December 1960, is soon to be available in an English Edition published jointly by Interscience Publishers, New York, and Sky Publishing Corporation of Harvard Observatory under the title *An Atlas of the Moon's Far Side: The Lunick III Reconnaissance*. It will include 30 photographs of the hidden side of the Moon. The price has been announced to be $7.50.

- **New Journal to Publish Translation of Soviet Papers in Chemical Engineering**—Selected technical papers in Chemical Engineering by Soviet authors in Russia, Eastern and Central Europe, and China will be published by the American Institute of Chemical Engineers in a new quarterly journal that is scheduled to appear in October 1961. The journal will receive financial aid from the National Science Foundation.

- **Mountain in Antarctica Named Mount Press**—A mountain in Antarctica has been named after Frank Press, Director of the Seismological Laboratory at California Institute of Technology, in recognition 'of the long and outstanding services rendered by him in the planning, organization and implementation of the United States Antarctic program during the International Geophysical Year.' The name was approved by the NAS Special Committee on IGY Geographic Names in the Antarctica, and the U. S. Department of the Interior.

Mount Press is in the Ellsworth Highland, in West Antarctica, between Marie Byrd Land and Edith Ronne Land, and about 700 miles from the South Pole.

- **Returns to Antarctic After 47 Years**—Sir Charles S. Wright, a member of the last Robert Falcon Scott expedition, in 1911–1915, has returned to the Antarctic as a scientist with the

U. S. Antarctic Research Program. Sir Charles, a physicist with the Pacific Naval Laboratories, Canadian Defence Research Board, is on loan to participate in the joint Stanford–PNR study of very low frequency radio waves, and will work at Byrd Station, Antarctica. Stanford received a grant of approximately $60,000 from the National Science Foundation in support of the project.

• **Building at 'Cal Tech' Named for Franklin Thomas**—The building at California Institute of Technology known as 'Engineering' has been renamed the 'Franklin Thomas Engineering Laboratory' in honor of the former Dean of Students and nationally known engineer. Dean Thomas died in 1952 after serving the Institute, community, and State for 39 years; he helped to solve some of Southern California's major water problems.

Personalia

• **Clarence R. Allen**, Associate Professor of Geology at California Institute of Technology, Pasadena, has received the first Grove Karl Gilbert Award, of $9000, to continue his studies of fault scarps of the Pacific Basin area.

• **Werner A. Baum**, since 1949 head of the Department of Meteorology, and recently Director of Research and Dean of the Graduate School at Florida State University, has been appointed Dean of the Faculties, the most important academic post in the University.

• **Arthur A. Brant**, Chief of Exploration for the Newmont Mining Company, Danbury, Connecticut, has finished a tour to various schools and groups throughout the country, as distinguished lecturer for the Society of Exploration Geophysicists.

• **Detlev Bronk**, President of the Rockefeller Institute and also President of the National Academy of Sciences, was recently elected an honorary member of the Brazilian Academy of Science, and was awarded an honorary doctorate by the University of Brazil.

• **Preston E. Cloud** of the U. S. Geological Survey was elected to membership in the National Academy of Sciences at the April convocation.

• **H. Velpeau Darling**, Vice President of Transportation Consultants, Inc., Washington, D. C., is on leave of absence to study water resources developments in Taiwan. He is heading a team of engineers under the Special Fund of the United Nations.

• **Walter S. Dix** of Washington, D. C., liaison officer for the Maps and Surveys Branch of TVA, was elected Vice President of the American Congress on Surveying and Mapping at its 21st Annual Meeting held in Washington in March.

• **Robert D. Elliott**, President of North American Weather Consultants, Santa Barbara, California, has received the American Meteorological Society's Award for Applied Meteorology, for effective leadership and administration in promoting meteorological research and its applications in private industry.

• **Nicholas V. Feodoroff**, Associate Professor of Civil Engineering at Manhattan College, New York, was recently elected a Fellow of the Royal Society for the Encouragement of Arts, Manufactures and Commerce, which was founded in London in 1660 and is said to be the oldest scientific society in the world.

• **Albert George Fiedler** retired on March 3 after more than 40 years service with the U. S. Geological Survey, in recent years as Assistant Chief of the Water Resources Division. He has received the Distinguished Service Award of the Department of the Interior, for outstanding leadership and contributions to the fields of hydrology and water resources.

• **Peter T. Flawn** has been appointed Director of the Texas Bureau of Economic Geology and Professor of Geology at the University of Texas; he succeeds the late John T. Lonsdale as State Geologist.

• **Scott E. Forbush** of the Carnegie Institution of Washington has been awarded the Charles Chree Medal and Prize of the British Institute of Physics and Physical Society for his work on cosmic radiation.

• **Robert B. Hickok**, for several years connected with the Ballistic Missiles Division of the U. S. Air Force at Los Angeles, has resumed work in soil and water research with the Watershed Technology Research Branch of the U. S. Department of Agriculture at Beltsville, Maryland, as Investigations Leader for Watershed Runoff Studies.

• **Woodrow C. Jacobs** of the Science and Technology Division of the Library of Congress, and Secretary of the Section of Meteorology, AGU, has been elected a Councillor of the American Meteorological Society.

• **Harold Jeffreys** of Cambridge University, England, AGU Bowie Medallist in 1952, has been awarded the Copley Medal of the Royal Society, London, in recognition of his outstanding contributions in several fields of geophysics, especially dynamical meteorology, seismology, radioactivity of rocks, and geodesy.

• **William W. Kellogg**, Chief of the Planetary Sciences Group of the RAND Corporation, Santa Monica, California, and member of the Science Board of the National Academy of Sciences, has been elected a Councillor of the American Meteorological Society. He has also received a special award of the Society for 'pioneering work in the planning of a meteorological satellite.'

• **Donald H. McLaughlin**, Chief Executive Officer of the Homestake Mining Company, was awarded the Rand Gold Medal at the annual meeting of the American Institute of Mining and Metallurgical Engineers, in recognition of his distinguished career in the mining industry, as an administrator in scientific education, and as an advisor to government.

- **Howard T. Orville**, late Captain USN, was posthumously honored by the American Meteorological Society's Charles Franklin Brooks Award for outstanding service to the Society.
- **E. F. Osborne** of Pennsylvania State University has been appointed to the Executive Committee of Sigma Xi.
- **Frank Press**, Professor of Geophysics and Director of the Seismological Laboratory at California Institute of Technology, Pasadena, has been appointed to a four-year term on The President's Science Advisory Committee.
- **Daniel F. Rex**, Captain USN, and Director of the Office of Development, U. S. Weather Bureau, has been elected a Councillor of the American Meteorological Society.
- **R. Robinson Rowe** of the California Division of Highways retired on November 30, 1960, but has been retained as principal bridge engineer for special studies.
- **Milton S. Sachs**, who retired from the Bureau of Reclamation in July, 1960, has recently been awarded the Interior Department's Citation for Distinguished Service.
- **Adrian E. Scheidegger** has left Imperial Oil Limited, Calgary, Ontario, and will be Visiting Professor of Geophysics at the University of Illinois, Urbana, through July, 1961; thereafter, he will join the mathematics Department at the University of Alberta, Calgary, Canada.
- **Henry M. Stommel**, Research Associate at the Woods Hole Oceanographic Institution, was elected to membership in the National Academy of Sciences at the April convocation.
- **Verner E. Suomi**, Professor of Meteorology at the University of Wisconsin, has received the Clarence LeRoy Meisinger Award of the American Meteorological Society for his 'imaginative and pioneering research work on atmospheric radiation problems.'
- **Robert G. Thomas** has resigned from the California Department of Water Resources, and is now Chief Engineering Geologist with Stetson, Strauss, and Desselhaus, Inc., of Los Angeles.
- **James Van Allen** of the State University of Iowa has been named by *Time* magazine as one of 15 scientists whose work 'shapes the life of every human presently inhabiting the planet.' Van Allen, a cosmic ray specialist, demonstrated the existence of the Van Allen radiation belts that surround the Earth.
- **Frank Lloyd Weaver** retired on April 14, after more than 25 years with the Federal Power Commission, recently as Chief of the Division of River Basins. He was also Advisor to the President's Water Resources Policy Commission.
- **Joseph V. B. Wells**, Assistant Chief of the Water Resources Division of the Geological Survey, has been designated River Master of the Delaware River.
- **Harry Wexler**, Director of Meteorological Research of the U. S. Weather Bureau, has received the Career Service Award of the National Civil Service League. This award is made each year to ten Federal employees chosen for 'competence, character, and outstanding achievements'.
- **George D. Whitmore**, Chief Topographic Engineer of the U. S. Geological Survey, has been elected a member of the Council of the International Society of Photogrammetry.
- **Jerome B. Wiesner**, of the Massachusetts Institute of Technology, has been appointed Science Advisor to President Kennedy.
- **Warren S. Wooster**, Associate Research Oceanographer at Scripps Institution of Oceanography since 1947, was appointed Director of the newly created Office of Oceanography of UNESCO, at the 11th session of the General Conference of UNESCO. He will make his headquarters at UNESCO in Paris.

- **Walter Ransom Gail Baker**, retired Electrical Engineer and formerly Vice President of the General Electric Company, died at his home in Syracuse on October 30, 1960. He was born in Lockport, N. Y., November 30, 1892. He obtained degrees of Bachelor of Engineering in 1916 and Master of Electrical Engineering in 1918, both from Union College. In 1935 Union College awarded him an honorary degree of Doctor of Science. He received an honorary degree of Doctor of Engineering in 1951 from Syracuse University, and another in 1955 from the Polytechnic Institute of Brooklyn. He joined the General Electric Research Laboratories staff in 1917 and had a prominent part in the development of radio during World War I; after the War he became Managing Engineer of the radio department. In 1929 he went to Camden, New Jersey, to head radio engineering activities of the RCA-Victor Corporation, of which he soon became Vice President and General Manager. In 1936 he returned to the General Electric Company, becoming Manager of its Radio and Television Department (now the Electronics Division) in 1939, a Vice President of the Company in 1941, and later Vice President and General Manager, Electronics Division, Electronics Park, Syracuse, N. Y. He was also President of the Syracuse University Research Corporation following his retirement in 1959. He received the Founders Award of the Institute of Radio Engineers in 1958. He joined the AGU in 1959.
- **James J. Doland**, Professor Emeritus of Hydraulic Engineering, University of Illinois, died at Urbana, Illinois, on December 23, 1960. He was born in Denver, Colorado on August 1, 1890. He graduated from the University of Colorado in 1914 with the degree of Bachelor of Science

in Civil Engineering; in 1927 he obtained the degree of Civil Engineer from the same institution. In 1932 he obtained the degree of Master of Science at the University of Illinois, and in 1945 was awarded an honorary Doctor of Science degree by St. Johns University. His teaching career of 32 years at the University of Illinois began in 1926, but in addition to this service, he was at various times a consultant for programs relating to water supply and related construction projects for public agencies. From 1936–1942 he was consultant for the National Resources Planning Board, and in 1943 and 1944 for the War Production Board. He was co-author of several books and handbooks in the water supply field. He was a Life Member of AGU, which he joined in 1939.

- **Henry Howard Finnell**, retired research specialist of the Soil Conservation Service, died at Westminster, California, September 7, 1960. He was born at Oakley, Mississippi, October 27, 1894. Upon graduation from the Oklahoma Agricultural and Mechanical College in 1917, he took a position as Agronomist at the Oklahoma Agriculture Experiment Station, with which he served until 1919, and again from 1923 to 1933. In 1934 he began a productive research career as Soil Conservationist with the U. S. Department of Agriculture, Soil Conservation Service. His active research in the southern Great Plains was marked by publication of many valuable papers on the problems of soil and water in relation to dry land agriculture. In May 1950 he was awarded the Superior Service Award of the Department of Agriculture. He had been a member of AGU since 1945.

- **Edgar E. Foster** of Santa Clara, California, retired Civil Engineer and specialist in hydrology, died in San Francisco on August 23, 1960. He was born in Vernon Center, Minnesota on January 25, 1894. Upon graduating from the University of North Dakota in 1922 with the degree of Bachelor of Science in Civil Engineering he joined the staff of the U. S. Geological Survey, Water Resources Branch, at Madison, Wisconsin, and was engaged in stream gauging there until 1924. He was an associate engineer with the U. S. Corps of Engineers from 1924 to 1944, assigned to various district offices, for work chiefly in flood control studies. From 1946 to 1953 he was with the Hydrology Division of the Bureau of Reclamation at Denver, Colorado; during this period he was employed on foreign projects in Guam, Okinawa, Northern Rhodesia, Nicaragua, and Iran. Mr. Foster entered private practice in 1953 and retired in 1958. He was author of numerous scientific and technical papers, and of a book, *Rainfall and Runoff*. He had been a member of AGU since 1939.

- **Thomas Geraci**, who from the inception of our William Bowie Medal has been the engraver on this Medal, and who has been the engraver on many important trophies and plaques relating to the activities of the renowned, died February 1, 1961, at his home in Washington, D. C. He was 67 years old.

- **William Irl Hicks**, retired civil engineer, died at Los Angeles, California on October 20, 1960. He was born in Denton, Texas, on June 16, 1892. He graduated from North Texas State Normal College in 1911. He obtained the degree of B.S. in Civil Engineering at Purdue University in June 1922 and then joined the engineering staff of the Bureau of Engineering of the City of Los Angeles, as topographical draftsman. In 1924 he was promoted to Civil Engineer with the Storm Drain Design Division, with which he was in continuous service until his retirement, June 10, 1960. His 38 years of service were marked consistently by high standards of work, recognized by scrolls presented to him by the City of Los Angeles and by his associates. He was author of several papers in his field of activity. He joined the AGU in 1950.

- **Esper Signius Larsen, Jr.**, Professor (emeritus) of Petrography at Harvard University and Geologist (retired) of the U. S. Geological Survey, died at his home in Washington, D. C., on March 8, 1961. He was born in Astoria, Oregon, on March 14, 1879. His father came to the United States from Denmark, as the first Danish Consul in Portland, Oregon. Professor Larsen obtained the degree of Bachelor of Science from the University of California in 1906, and a doctorate from the same institution in 1918.

From 1906 to 1907 he was Instructor in Geology and Mineralogy at the University of California. From 1907 to 1909 he was Assistant Petrographer at the Geophysical Laboratory of the Carnegie Institution, Washington, D. C. In 1909 he went to the United States Geological Survey as Geologist, and was in charge of the Section of Petrology from 1918 to 1923. He joined the faculty of Harvard University in 1923, as Professor of Petrography and Mineralogy. Upon his retirement from Harvard in 1949 he returned to the Geological Survey, where he remained active until 1958.

Professor Larsen was author of more than 100 publications in the science of geology. He achieved an international reputation for his work on optical properties of minerals, on the identification and description of many new mineral species, on the geology and petrology of the San Juan Mountains of Colorado and also of a large area in southern California, on the distribution of minor elements (particularly uranium) in rocks, and on the development of methods for the measurement of geologic time. He was recipient of the Penrose Medal of the Geological Society of America, and of the Roebling Medal of the Mineralogical Society of America—the highest awards of these organizations.

He was a Past President of the Geological Society of America, a past Vice President of the Mineralogical Society of America, and a member of the National Academy of Sciences; he also held membership in several other national and international professional organizations. He had been a member of AGU since 1929.

• **Jens M. Lyshede**, of Copenhagen, Denmark, died on January 5, 1961. He was born in Torslev, Denmark, on November 1, 1911. After obtaining his doctorate in physics at Copenhagen University he engaged in research and teaching at the Institute of Theoretical Physics at Copenhagen. In 1956 he became Professor of Physics and Meteorology at the Royal Veterinary and Agricultural College, Copenhagen, a position he held at the time of his death. His principal work and interests were in the fields of hydrology and meteorology in which he became well known, particularly for his investigations of Danish water courses. He was President of the Danish Geophysical Society from 1957 to 1960. He became a member of AGU in 1960.

• **Frank C. Merriell** of Grand Junction, Colorado, formerly Chief Engineer of the Colorado River Water Conservation District, died on January 24, 1961. He was born in Oak Park, Illinois, November 15, 1885. He graduated from Colorado College in 1909 with the degree of Bachelor of Science in Electrical Engineering. After several years of engineering practice with railway and power companies, in the fields of railway and highway location, and related problems, he entered the field of hydrology, and for many years, beginning in 1922, he worked on problems connected with the Colorado River, and on irrigation problems in western Colorado. In 1935–1936 he was director of the WPA program in western Colorado, and from 1936–1938 an engineer with the Bureau of Reclamation. In his later years he practiced as a private consultant. He joined the AGU in 1951.

• **Marvin Harold Oleson**, of the U. S. Air Force Technical Application Center, Alexandria, Virginia, was killed in an automobile accident January 22, 1961. He was born in Dallas, South Dakota, May 17, 1909. In 1931 he obtained a degree of Bachelor of Arts at St. Olaf College, majoring in Physics. He took post-graduate courses in physics at the University of Texas in 1937, and in 1945 completed requirements for the degree of Electrical Engineer at the University of Maryland. From 1937–1941 he was engaged in seismographic work with the Petty Geophysical Engineering Company. In 1941 he joined the staff of the Naval Ordnance Laboratory at Silver Spring, Maryland. In 1950 he became a project officer with the U. S. Air Force, Research and Development Division; he was transferred to the Technical Applications Center in 1959 where he was engaged in the initiation and administration of Research and Development projects. He joined the AGU in 1959.

• **Carl Gustave Paulsen**, formerly Chief Hydraulic Engineer of the U. S. Geological Survey, died on January 30, 1961, at Caldwell, Idaho. He was born in Chicago, Illinois, April 22, 1887, and was educated in the public schools in Chicago and Idaho. He earned the Bachelor of Science and Civil Engineer degrees at the University of Idaho, and in 1959 was awarded an honorary doctorate by that University in recognition of his public services. He began his professional career in 1911 as a hydrographer with the Bureau of Reclamation. In 1914 he joined the Geological Survey as a junior hydraulic engineer. In 1917 he was commissioned in the Engineer Corps of the U. S. Army and assigned, by Presidential order, to special duty in this country. After the close of World War I he became district engineer of the Geological Survey for the Idaho district. In 1931 he was assigned to the Washington office of the Survey as Chief of the Surface Water Branch; he became Chief Hydraulic Engineer, in charge of the Water Resources Division, in 1946. He served at various times on several State and Federal Commissions, and the International Joint Engineering Boards relating to water distribution problems concerning joint interests of Canada and the United States. During World War II he served as civilian consultant of the Central Intelligence Agency. Later he was appointed by the United Nations to a commission for planning development of the Mekong River between Laos, Thailand, and Cambodia. In 1957 he was awarded the Distinguished Service Medal by the Department of the Interior. He joined the AGU in 1931, and became a Life Member in 1957.

• **Charles Collingwood Zimmerman**, President of Keystone Development Corporation, and of Keystone Instruments, Inc., died on January 31, 1961. He was born in Pittsburgh, Pennsylvania on April 23, 1905. His family moved to Tulsa, Oklahoma during his high school years, and he started his college education at the University of Tulsa, but transferred to the University of Pittsburgh, where he graduated in 1926; he received an M. S. degree there the following year. He majored in geology and petroleum engineering, then entered the field of geophysics. In 1928 he became a magnetometer operator with The Texas Company and became Assistant Chief Physicist in 1939. In 1943 he resigned to organize the Keystone Exploration Company, and later participated in forming the Keystone Development Corporation. He developed several geophysical instruments for use in petroleum industry, among them an accoustical well-sounder, a 3-component well detector, an automatic recording device, and pressure geophones for use in water. He had been a member of AGU since 1938.

Union, Section, and Committee Activities

Forty-Second Annual Meeting (1961)

Minutes, General Assembly and Section Meetings

Smoker

The Smoker was held in the Grand Ballroom of the National Press Club, National Press Building, Fourteenth and F Streets, N.W., Washington, D. C., on Wednesday, April 19, 1961. More than 500 persons attended. As usual, this was an informal gathering with no planned program or entertainment, but it provided excellent opportunities for those in attendance to get into touch with old friends and to meet new acquaintances. There was a great milling about and shifting from table to table and from nook to nook, and the affair was lauded generally, as a very important function of AGU's meeting.

General Assembly: Papers on Frontiers in Geophysics, and Business Meeting

The General Assembly was called to order by Vice President Thomas F. Malone at 14h 00m on Thursday, April 20, 1961, in the Great Hall of the National Academy of Sciences. After an appropriate introductory statement, the following program was presented:

(1) ROBERT R. NEWTON: Potential Geodetic Applications of the Transit Satellite
(2) SIGMUND FRITZ: Geophysical Implications of Tiros I Photographs
(3) JOHN I. EWING: Recent Developments in Marine Geophysics
(4) WILLARD N. BASCOM: Scientific Findings of the Experimental Deep-Sea Drilling

About 250 attended. Brief discussion followed each paper. At the close of the discussion on the fourth paper, the business meeting was called to order.

The minutes of the Forty-First Annual Meeting were reported in the *Transactions* of June 1960 (Vol. 41, pp. 334–337); as no corrections have been received the minutes were deemed to be approved.

SUMMARY OF THE GENERAL SECRETARY'S REPORT

In the absence of General Secretary Sayre, the Executive Secretary, Waldo E. Smith, reviewed the activities for the past year, briefly noting that the affairs were reported in considerable detail in the minutes of the Executive Committee (September 1960 *Transactions*, pp. 457–484; December 1960 *Transactions*, p. 681; and the March 1961 *Transactions*, pp. 63–97). The Executive Committee has been superseded by the new Council. Minutes of the first meeting of the Council, held on April 22, will appear in the September 1961 issue of the Transactions, and will give details regarding the financial position of AGU and receipt of grants; they will specifically note that the dues for 1962 have been increased from $10.00 to $13.00 for members, and from $4.50 to $5.00 for student members. Members receive the monthly *Journal of Geophysical Research* as well as the *Transactions* for the payment of dues, and special discounts, generally 20 per cent, on publications of the Union.

It was noted that, in the elections held in December, Thomas F. Malone has been elected President; George P. Woollard, Vice President; and A. Nelson Sayre reelected General Secretary for the interval July 1, 1961 to June 30, 1964.

Information concerning membership, publications, the translation program, and other matters, is covered in full detail in the minutes cited above.

REPORT OF THE PRESIDENT

In the absence of the President, the Vice President noted that, at its meeting on March 25, the Executive Committee of the Council had commended Editors Philip H. Abelson and James A. Peoples, Jr., for the outstanding work they have done in making the *Journal of Geophysical Research* the World's outstanding publication in the field of geophysics. He also cited the splendid work done by the staff of AGU in relation to the affairs of the Union during the past year, and especially offered commendations to those who were responsible for the arrangements for the Annual Meeting.

He noted further that much of our endeavor during the next months will be devoted towards the Thirteenth General Assembly, which is to be held in Berkeley, California, August 19–31, 1963. Committees are being organized, and many members will be called upon to help so that the IUGG meeting may be carried off with distinction.

REPORTS OF STANDING COMMITTEES

In the absence of the Chairman of the Committee on the Eastern Meeting, L. Thomas Aldrich, it was noted that the arrangements for the meeting to be held in the week immediately preceding the National Academy Meeting had seemed to work out exceedingly well, and that recommendation would be made to the Council on April 22 that the same relationship of these meetings be maintained next year; accordingly the 1962 Annual Meeting presumably will be held April 17 to 21.

REPORTS OF SPECIAL COMMITTEES

Resolutions—Chairman Helmut Landsberg presented the following resolutions, which were approved unanimously:

(1) RESOLUTION OF THANKS FOR THE USE OF FACILITIES FOR THE REGIONAL MEETING AT BERKELEY, CALIFORNIA

WHEREAS, The success of the Pacific Southwest Regional Meeting at Berkeley, California January 26 and 27, 1961 was due in large part to the space and facilities generously provided by the University of California, Berkeley, therefore be it

RESOLVED, That the American Geophysical Union express its great appreciation to the University of California, Berkeley, for the use of its meeting rooms and other facilities, and request the Executive Officer of the National Academy of Sciences to express the thanks of the Union to the Chancellor of the University of California, Berkeley.

(2) RESOLUTION OF THANKS FOR THE USE OF FACILITIES FOR THE FORTY-SECOND ANNUAL MEETING

WHEREAS, The National Academy of Sciences has provided the use of meeting rooms and other services for the Forty-Second Annual Meeting of the American Geophysical Union, therefore be it

RESOLVED, That the American Geophysical Union express its great appreciation of this cooperation, extended over many years, and instruct the General Secretary to express the thanks of the Union to the appropriate official.

(3) RESOLUTION OF THANKS FOR THE USE OF FACILITIES FOR THE FORTY-SECOND ANNUAL MEETING

WHEREAS, The District of Columbia Chapter of the American Red Cross, the United States Public Buildings Administration, the Department of State, the National Science Foundation, and the Department of the Interior provided the use of their auditoria for the Forty-Second Annual Meeting of the American Geophysical Union, therefore be it

RESOLVED, That the American Geophysical Union express its great appreciation of this cooperation and request the Executive Officer of the National Academy of Sciences to express the thanks of the Union to the appropriate officials.

(4) RESOLUTION SUPPORTING THE CONSTRUCTION OF A HEADQUARTERS BUILDING FOR THE WEATHER BUREAU

WHEREAS, The Weather Bureau of the United States Department of Commerce is engaged in programs of vital importance to the economy and defense of the nation; and

WHEREAS, The headquarters of the United States Weather Bureau are located in various inadequate and inefficient buildings scattered throughout the Washington, D. C. area, be it

RESOLVED, That the American Geophysical Union support the conclusions of the Kelly Committee report with respect to Weather Bureau Buildings, and express to the Secretary of Commerce the hope that remedial action on existing deficiencies can be taken.

Adjournment—The Business Meeting adjourned at 16h 37m.

A. NELSON SAYRE, *General Secretary*
WALDO E. SMITH, *Executive Secretary*

Banquet

For the first time, the American Geophysical Union joined with the American Meteorological Society, with whom the Section of Meteorology held joint scientific sessions, for the banquet which has been an annual affair of the AMS for some years. About 260 people attended. The banquet was held in the Ballroom of the Washington Hotel, at Fifteenth Street and Pennsylvania Avenue, on Thursday, April 20.

Vice President Thomas F. Malone, who is also President of the American Meteorological Society, presided. He first introduced those at the head table and those at the reserved tables, including J. Tuzo Wilson of Canada, retiring President of the IUGG, and V. V. Beloussov of the USSR, currently President of the IUGG. He then presented Leason H. Adams, who made the citation concerning the Twenty-Third William Bowie Medalist, Keith E. Bullen of the University of Sydney, Sydney, Australia, as set forth on page 149 of this issue of the *Transactions*. The presentation was made by Maurice Ewing, Chairman of the William Bowie Medal Committee. It was not possible for Professor Bullen to be present; T. B. Paltridge, Science Attache of the Australian Embassy, accepted the Medal on behalf of Professor Bullen and read Professor Bullen's acceptance and response as set forth on pages 150–152 of this issue. Following this ceremony, two honorary memberships of the American Meteorological Society were made, on the basis of citations by Patrick D. McTaggart-Cowan, to Sigekata Syono (received on his behalf by Seiichi Ishizaka of the Japanese Scientific Mission) and to Paul Klopsteg, Special

Consultant to the National Science Foundation and Chairman of the Personnel Security Review Board of the Atomic Energy Commission. Chairman Malone then introduced George B. Kistiakowsky, Abbott and James Lawrence Professor of Chemistry at Harvard University, and formerly Science Adviser to President Eisenhower, who talked on the subject *Is Long-Range Planning for Basic Research Necessary?*

The banquet adjourned about 22h 20m.

APPENDIX A—Minutes of the Annual Meeting of 1961, Planning Committee on Planetary Sciences

The following 87 papers were presented in the sessions arranged by the Planning Committee on Planetary Sciences. Of these, 43 papers were presented in sessions arranged jointly by the Secretaries of the Planning Committee on Planetary Sciences and the Section of Geomagnetism and Aeronomy. The sessions were attended by an average audience of 200, with a peak attendance of 300.

Wednesday, April 19, 09h 00m, Auditorium, New State Department Building, *Moon and Planets* (P. H. Abelson, Chairman):

(1) A. G. Smith, T. D. Carr, N. E. Chatterton and Heins Bollhagen: Spectral Distribution of the Decameter-Wavelength Radiation from Jupiter
(2) Leverett Davis, Jr., and David B. J. Chang: Synchrotron Radiation as the Source of Jupiter's Polarized Decimeter Radiation
(3) E. H. Vestine: Some Aspects of the Survey of the Magnetic Field of the Moon and Planets
(4) Wm. Markowitz and R. G. Hall: Speed of Rotation of the Earth and Solar Activity
(5) Thomas Gold: Permafrost on the Moon
(6) C. D. Schrader and R. J. Stinner: Remote Analysis of Surfaces by Neutron-Gamma Inelastic Scattering Technique
(7) Gustav Arrhenius: Petrological Studies of the Surface of the Moon: Some Plans and Development for Telemetered Experiments
(8) J. A. O'Keefe and Winifred Sawtelle Cameron: Gravitational Evidence of Differentiation on the Moon
(9) P. D. Proctor, G. C. Amstutz and R. A. Black: Lunar Tectonics and Near-Surface Lunar Composition
(10) K. J. K. Buettner: The Lunar Surface
(11) K. von Bulow, J. Green and G. C. Amstutz: Structural Features of the Moon
(12) S. F. Singer and E. N. Walker: A Lunar Ionosphere
(13) H. W. Briscoe, L. G. Kraft, G. H. Pettengill, R. Price: Radar Observations of Venus During the 1961 Inferior Conjunction
(14) K. Watson, B. Murray and H. Brown: A Model of Solid-Vapor Phase Equilibria on the Lunar Surface
(15) A. C. Mason: Lunar Limb Slope Profile

Wednesday, April 19, 1961, 14h 00m, Auditorium, State Department: *Meteorites* (Edward Anders, Chairman):

(16) Alvin J. Cohen: A Semi-Quantitative Asteroid Impact Hypothesis of Tektite Origin
(17) Peter Signer: Cosmogenic and Radiogenic Rare Gases in Chondrites
(18) A. G. W. Cameron: Anomalous Isotopic Composition of Xenon in the Earth's Atmosphere
(19) D. Heymann and O. A. Schaeffer: Exposure Ages of Some Iron Meteorites
(20) J. Geiss, H. Oeschger and P. Signer: Radiation Ages of Chondrites
(21) E. C. T. Chao: Metallic Spherules in Tektites from Isabella, Philippine Islands
(22) B. Nagy, W. G. Meinschein, and D. J. Hennessy: Mass Spectroscopic Analysis of the Orgueil Meteorite. Evidence for Biogenic Hydrocarbons
(23) T. Massalski and F. R. Park: A Quantitative Metallographic Study of Octahedrite Meteorites
(24) G. G. Goles and E. Anders: New Results on the Distribution of Iodine Among Meteoritic Phases
(25) R. Davis, Jr., and R. W. Stoenner: Calculation of the Argon Radioactivities Produced by Cosmic Radiation in Small Meteorites
(26) Virgil Barnes: Observations of Meteorite Craters

Wednesday, April 19, 16h 30m, Auditorium, State Department, *Special Session on Explorer X:*

(27) J. P. Heppner, T. L. Skillman, C. S. Scearce, and N. F. Ness: Preliminary Results of Interplanetary Magnetic Field Measurements from Explorer X
(28) H. Bridge, A. Lazarus, C. F. Lyon, B. Rossi, and F. Scherb: Preliminary Results of Plasma Measurements on Explorer X
(29) S. Olbert and B. Rossi: Considerations on the Magnetic Sphere and the Interplanetary Plasma

Thursday, April 20, 8h 30m, Auditorium, Department of the Interior: *Trapped Particles* (J. A. Van Allen, Chairman), joint session with Section of Geomagnetism and Aeronomy:

[a] *Properties*

(30) Z. F. Danes: Numerical Solutions of Radiation Belt Parameters
(31) R. C. Wentworth and W. M. MacDonald: The Possible Absence of Equatorial Orbits for Geomagnetically Trapped Electrons
(32) Darrell L. Judge and Paul J. Coleman, Jr.: Betatron Acceleration of Geomagnetically Trapped Particles: Explorer VI
(33) D. A. Kniffen and J. E. Naugle: Proton Fluxes in the Inner Van Allen Belt
(34) Carl E. McIlwain: On the Application of the Adiabatic Invariants to the Interpretation of Trapped Particle Fluxes in the Earth's Magnetic Field
(35) Ernest C. Ray: On the Inner Zone of Trapped Radiation
(36) Alan Rosen: Dynamics of the Outer Van Allen Radiation Zones
(37) S. E. Forbush, D. Venkatesan, and C. E. McIlwain: Intensity Variations in the Outer Van Allen Radiation Belt

[b] *Geophysical Effects* (10h 30m)

(38) C. Y. Fan, P. Meyer, and J. A. Simpson: Dynamics of the Outer Radiation Belts
(39) George D. Freier: Auroral Effects on the Earth's Electric Field
(40) Alfred J. Zmuda: Auroral Currents
(41) E. J. Smith and D. L. Judge: Transient Variations in the Extraterrestrial Magnetic Field: Explorer VI
(42) S. F. Singer: Dust Shell Around the Earth
(43) J. R. Apel and S. F. Singer: Magnetic Effects of Trapped Particles
(44) A. J. Dessler and Robert Karplus: Neutron Decay and the Changes in the Van Allen Radiation Belt
(45) J. M. Okada: Electric Field Effects on Stormer Q-Regions
(46) Naoshi Fukushima: Local Increase of Geomagnetic Activity During the Decaying Stage of Magnetic Storms
(47) John W. Kern: Geomagnetic Field Distortion by Solar Streams as a Mechanism for Production of Polar Aurora and Electrojets

Thursday, April 20, 13h 30m, Auditorium, Department of the Interior:

[a] *Interplanetary Plasma* (John A. Simpson, Chairman)

(48) Thomas Gold: Present Evidence for Particle Fluxes and Fields in the Solar System
(49) P. J. Coleman, Jr., C. P. Sonett and Leverett Davis, Jr.: On the Interplanetary Magnetic Storm: Pioneer V
(50) H. Carmichael and J. F. Steljes: Evidence for Storage of Solar Cosmic Rays Within the Magnetic Configuration Responsible for a Forbush Decrease
(51) Tatsuzo Obayashi: Propagation of Solar Particles Through Interplanetary Space
(52) John R. Spreiter and Benjamin R. Briggs: Theoretical Determination of the Form of the Boundary of the Solar Corpuscular Stream Produced by Interaction with the Magnetic Dipole Field of the Earth
(53) James Hurley: Interaction between the Solar Wind and the Geomagnetic Field
(54) Conway W. Snyder: Interplanetary Space Experiments for the Venus Probe Mariner A
(55) Robert F. Doolittle and Carl D. Graves: The Scintillation Chamber: A New Tool for Space Physics

[b] *Solar Cosmic Rays: Solar Physics;* 15h 30m (John Winckler, Chairman; joint session with Section of Geomagnetism and Aeronomy):

(56) Philip A. Goldberg: Cosmic-Ray Induced Atmosphere Refractivity at Extra Low Frequencies
(57) Donald E. Cotten: Implications of Diurnal Variation in IGY Neutron Monitor Count Rates
(58) P. D. Bhavsar: Gamma Rays from the Solar-Ray Produced Nuclear Reactions in the Earth's Atmosphere
(59) E. P. Ney and W. Stein: Solar Cosmic Rays in November 1960
(60) Phyllis Freier, S. Biswas and W. Stein: Solar Protons and Alpha Particles from the September 3, 1960, Flare
(61) C. E. Fichtel and D. E. Guss: Nuclear Emulsion Studies of Solar Proton Beams
(63) R. R. Brown, T. R. Hartz, B. Landmark, H. Leinbach and J. Ortner: Large-Scale Electron Bombardment of the Atmosphere at the Sudden Commencement of a Geomagnetic Storm
(63) R. R. Brown and R. G. D'Arcy: Nuclear Reactions of Solar Protons in the Atmosphere, July 1959
(64) L. E. Peterson: Gamma-Ray Astronomy Experiment
(65) J. M. Malville and G. E. Moreton: The Association of the Explosive Phase of Flares with Type III Radio Bursts

Friday, April 21, 09h 00m, Auditorium, Department of the Interior, Joint Session with Section of Geomagnetism and Aeronomy

[a] *Atmosphere of the Planets* (J. W. Chamberlain, Chairman):

(66) Francis S. Johnson: Particle Energy in the Telluric Hydrogen Corona
(67) L. G. Smith: Electron Density Measure-

ments by the Asymmetrical Bipolar Probe

(68) E. J. **Öpik**: The Areolosphere and Atmosphere of Venus

(69) **Gilbert Yanow**: A Model of the Martian Upper Atmosphere and Ionosphere

(70) **Heinrich D. Holland**: On the Chemical Evolution of the Earth's Atmosphere

(71) G. P. **Serbu**: Results from a Rocket-Borne Langmuir-Probe Experiment

(72) A. **Rudolf Hanel and** W. G. **Stroud**: The Tiros II Radiation Experiments

(73) C. E. **Leith**: A Five Level Model of the Atmosphere Using Primitive Equations

(74) H. E. **Edwards**: Upper Atmosphere Winds Between 100 and 125 km from the Chemical Release Program

(75) J. C. **Cain**, J. P. **Heppner**, I. R. **Shapiro, and** J. D. **Stolarick**: Observations of Audio-Frequency Signals Above the Ionosphere

[b] *Hydromagnetic Effects*, 11h 00m (A. J. Dessler, Chairman):

(76) **Masahisa Sugiura**: Evidence of Hydromagnetic Waves in the Earth's Magnetic Field

(77) **Lee R. Tepley**: On Hydromagnetic Whistlers

(78) A. J. **Dragt**: Effect of Hydromagnetic Waves upon Van Allen Protons

(79) W. H. **Campbell**: Auroral Zone Short-Period Micropulsations

(80) J. **Renau**, W. **Flood, and** H. **Camnitz**: The Spectrum and the Total Intensity of Scattered Electromagnetic Waves from an Ionized Gas in Thermal Equilibrium and the Presence of a Uniform Magnetic Field

Friday, April 21, 9h 00m, Lecture Room, National Academy of Sciences (Frank McDonald, Chairman):

(81) **Stanley** C. **Freden and** R. **Stephen White**: Protons in the Inner Radiation Belt

(82) J. **Killeen and** W. N. **Hess**: Spatial Distribution of Electrons From Neutron Decay in the Outer Radiation Belt

(83) H. H. **Heckman and** A. H. **Armstrong**: The Flux and Spectrum of Low Energy Protons in the Lower Van Allen Belt

(84) **Keith** W. **Ogilvie and** L. R. **Davis**: Rocket Observations of Solar Protons

(85) **Constance** S. **Warwick**: Polar Cap Absorption Events and the Interplanetary Magnetic Field

(86) **Frank** C. **Jones**: Generation of Low-Energy Gamma Rays in the Atmosphere

(87) K. G. **McCracken**: Interplanetary Magnetic Fields as Derived from Cosmic-Ray Observations

Friday, April 21, 14h 00m, Auditorium, Department of the Interior, *Summary of the Highlights of the Planetary Sciences Program by the Session Chairmen* (Harold C. Urey, Chairman)

APPENDIX B—Minutes of the Annual Meeting of 1961, Section of Geodesy

The Forty-Second Annual Meeting of the Section of Geodesy was called to order by President Charles Pierce at 09h 16m on April 18, 1961, in the Auditorium, National Science Foundation. Officers of the Section for the next triennium were introduced. The minutes of the Forty-First Annual Meeting were approved as published in the Transactions of June 1960. The President reported on the possibility of setting up a Visiting Scientists Program for Geodesy; a committee will be appointed to make a study of the needs for this program.

The scientific session proceeded with the following papers (for joint papers the speaker is indicated with an asterisk):

(1) **Milton** O. **Schmidt**: Geodetic Engineering Education in Western Europe

(2) **Gerald Joyner* and Peter Dehlinger**: Surface-Ship Gravity Measurements in the Gulf of Mexico, Aboard the Hidalgo, in June 1958

(3) O. S. **Strickholm* and** J. C. **Rose**: A Discussion of the Pendulum Gravity Interval between Washington, D. C., and Ottawa, Ontario

(4) G. P. **Woollard and** J. C. **Rose***: An Evaluation of the World's Gravity Control

(5) J. C. **Rose* and** O. S. **Strickholm**: Reliability of Pendulum Gravity Intervals between Absolute Sites in Europe and North America

(6) **Emanuel** M. **Sodano**: Optimum General Solution to the Inverse, Direct and Intersection Problems of Spheroidal Geodesics

The session recessed at 12h 10m and reassembled at 14h 02m with President Pierce presiding. The following papers were presented:

(7) **Bruce** C. **Murray**: Special Geophysical Applications of Precise Satellite Velocity Observations

(8) **Donald** A. **Rice**: A Geoidal Section along the 35th Parallel

(9) **Irene Fischer**: The Geometric Parallax of the Moon

(10) A. C. **Holland**: The Effects of Atmos-

pheric Refraction on Angles Measured from a Satellite

(11) I. G. Izsak and Y. Kozai*: Equipotential Surfaces of the Earth as Obtained from Satellite Motions

(12) Roman K. C. Johns: Theoretical Study on Probability of Simultaneous Satellite Observations

(13) W. A. Heiskanen: On the Ellipticity of the Earth's Interior

The meeting adjourned at 16h 46m.

B. K. Meade, *Secretary*

APPENDIX C—Minutes of the Annual Meeting of 1961, Section of Seismology

President Murphy called the meeting to order at 09h 7m on Tuesday, April 18 in the Lecture Hall of the National Academy of Sciences. The minutes of the previous meeting were reported to have been published in the *Transactions*. No old or new business needed action. President Murphy reported on the IUGG program on the upper mantle and crust.

The scientific session began at 09h 20m with President Murphy and President-elect Peoples as co-chairmen. The following papers were presented (asterisk denotes the speaker for joint papers):

(1) Gerald R. MacCarthy: Earthquakes of the Eastern United States: a Progress Report

(2) Maurice Blaik: Deep-Hole Noise Correlation and Spectra

(3) E. A. Flinn, C. F. Romney*, A. M. Rugg, and J. R. Woolson: Analytical Results from Low-Frequency Seismic Measurements in a Deep Well

(4) J. C. DeBremaecker*, Paul Donoho, and G. P. McCouch: An Electronic Digital Seismograph

(5) G. H. Sutton*, G. V. Latham, M. Ewing: Long-period Feedback Seismographs

(6) Stewart W. Smith: Fine Structure of the Earth's Spectrum

(7) George Backus, and Freeman Gilbert*: Rotational Splitting of the Free Oscillations of the Earth

The sessions recessed at 12h 13m, and reconvened at 14h 01m with Vice-President elect Oliver and L. B. Slichter as co-chairmen. The following papers were presented:

(8) Paul A. Siple: Seismic Correlations with Polar Motion Data

(9) E. Thiel*, and N. A. Ostenso: Seismic Studies on Antarctic Ice Shelves

(10) J. W. Berg, Jr.,* K. L. Cook, H. D. Narans, Jr., and R. J. Leamer: Seismic Profiles in Northwestern Utah: Pilot Range and Grouse Creek Range Area

(11) J. S. Steinhart*, and G. P. Woollard: Linear Analysis of Explosion Seismic Results on the Continents

(12) Ira H. Cram, Jr.: A Crustal-Structure Refraction Survey in South Texas

(13) Ari Ben-Menahem: The Theory of Radiation of Surface Waves from Finite Sources

(14) Frank Press*, Ari Ben-Menahem, and N. Toksoz: Experimental Determination of Fault Length and Rupture Velocity

(15) R. P. Meyer*, and W. E. Bonini: Crustal Measurements in the Montana-North Dakota Area

(15A) H. M. Iyer: Computation of Microseismic Noise in the Deep Ocean

The session recessed at 17h 08m, and reconvened on Wednesday, April 19 at 9h 03m with D. C. Carder and Frank Press as co-chairmen. The following papers were presented:

(16) C. Kisslinger*, E. J. Mateker, Jr., and T. V. McEvilly: SH Motion from Explosions in Soil

(17) J. Northrop*, M. Blaik: T-phases from the Dominican Republic Earthquake of September 14, 1960

(18) B. A. Bolt, and J. Dorman*: Phase and Group Velocities of Rayleigh Waves in a Spherical Gravitating Earth

(19) J. T. Kuo*, James N. Brune, and Maurice W. Major: Rayleigh-Wave Dispersion in the Pacific Ocean for the Period Range 20 to 140 seconds

(20) James Brune, Maurice Ewing, and John Kuo*: Group Velocities for Rayleigh Waves of Period Greater than 380 Seconds

(21) P. W. Pomeroy*, and Jack Oliver: Seismic Surface Waves from Large, Near-Surface Nuclear Explosions

(22) Freeman Gilbert*, and S. J. Laster: Excitation and Propagation of Pulses on an Interface

(23) Freeman Gilbert*, and S. J. Laster: Experimental Investigation of PL Modes in a Single Layer

The session adjourned at 11h 52m.

B. F. Howell, Jr., *Secretary*

APPENDIX D—Minutes of the Annual Meeting of 1961, Section of Meteorology

The Forty-Second Annual Business Meeting of the Section of Meteorology was called to order by President Malone at 09h 15m, April 18, 1961, in the Auditorium of the American Red Cross Building. The President announced the following results of the triennial election of officers for the Section: Morris Neiburger, President; Henry G. Houghton, Vice President; and Woodrow C. Jacobs, Secretary. He then turned the meeting over to President-elect Neiburger.

The minutes of the Forty-First Annual Meeting were approved as published (*Transactions* 41, 340-343, 1960).

A Resolutions Committee was appointed, to consist of Jack Thompson, Chairman, and Hans A. Panofsky.

The first business meeting then adjourned at 13h 30m.

A second business session was called by President-Elect Neiburger at 13h 00m, April 19, 1961, to consider two resolutions submitted to the Resolutions Committee by members of the Section.

The first resolution was submitted by Conrad Mook and dealt with the matter of expediting action on a new home for the U. S. Weather Bureau. The resolution was approved as submitted and forwarded to the Union Resolutions Committee under the chairmanship of H. E. Landsberg (See AGU Resolution Number 4).

A second resolution, submitted by James E. McDonald of the University of Arizona, was approved as submitted, and passed on to the Section officers for action. The resolution reads as follows:

> Whereas, in the event of nuclear war, enemy attack on our continental missile bases may create local radioactive fallout of extremely high radiological intensities, and
>
> Whereas, consideration of meteorological and climatological factors governing drift of fallout in planning for missile base deployment may reduce fallout hazards to populated areas,
>
> Be It Resolved that the Section of Meteorology of the American Geophysical Union urge the appropriate military and civil defense agencies immediately to carry out a thorough examination of the hazards which may result from locating fixed base intercontinental missiles close upwind of population centers with a view to locating all future installations in places which minimize such hazards to populated areas.

The meetings were exceptionally well attended, particularly the sessions on Satellite Meteorology, the High Atmosphere, and Research—Current and Future. There were 439 registrations for the meetings recorded at the meteorological desk in the Red Cross Building, but actual attendance was perhaps double this number.

All sessions were held in the Auditorium of the D. C. Chapter, American Red Cross, except as noted otherwise.

The scientific sessions, held jointly with the American Meteorological Society, consisted of the following papers:

Tuesday, April 18, 1961, 09h 00m, *General Meteorology*, (Jack Thompson, Chairman):

(1) H. W. Albers and J. F. Miller: The Navy's Ship Routing Program
(2) Hans A. Panofshy: Scale Analysis of Meteorological Motions at Two Meters
(3) Henry A. Salmela: Wind Speeds GMD-1 Ascents Computed Electronically Compared to Plotting Board Results
(4) F. Pooler, Jr.: Stable Air-Flow Patterns at Louisville, Ky.
(5) James E. McDonald: An Analysis of Fallout Hazards from ICBM Sites Located Upwind of Cities
(6) Milo J. Andre: Use of Climatic Transition Probabilities in Problems of Applied Climatology and Extended Forecasting
(7) Nicholas Manos: Weather, Statistics, and Health (An Index of Air Pollution and Its Relation to Health)

Tuesday, April 18, 14h 00m, *Numerical Weather Predictions*, (Hugh W. Ellsaesser, Chairman):

(8) Harold A. Bedient: The Increased Data Processing Capacity of the National Meteorological Center
(9) Mirco P. Snidero: Data Processing at JNWP
(10) John A. Brown, Jr.: The JNWP Operational Analysis Program
(11) James R. Neilon: Results of Automation in Map Production at the JNWP Unit
(12) Henry P. Marx: Processing Observed Data for Automatic Entry into Weather Computers
(13) Billy M. Lewis: Further Technological Advances in Automating extended and Long-Range Forecasting Procedures
(14) Louis Berkofsky: A Generalized Form for Vertically Integrated Numerical Forecasting Models
(15) Yoshikazu Sasaki: Effects of Condensation, Evaporation, and Rainfall on the Development of Mesoscale Disturbances; a Numerical Experiment

Wednesday, April 19, 09h 00m, *Satellite Meteorology*, (Charles Bristor, Chairman):

(16) John F. Clark: The NASA Geophysics Satellite Program
(17) David S. Johnson: Meteorological Satellite Research and Applications

(18) **H. M. Johnson**: Tropical and Subtropical Atmospheric Systems Observed by Tiros I
(19) **John Schuetz and Sigmund Fritz**: Satellite Pictures of Cloud Streets
(20) **A. F. Krueger, Jr., and Sigmund Fritz**: Cellular Cloud Patterns Revealed by Tiros I
(21) **Linwood F. Whitney, Jr., and Sigmund Fritz**: A Tornado-Producing Cloud Pattern Seen from Tiros I
(22) **Sigmund Fritz and Jay S. Winston**: Some Radiation Results from Tiros II
(23) **Harold B. Tolefson and Robert M. Henry**: A Method for Obtaining Detailed Wind-Shear Measurements for Application to Dynamic Response Problems of Missile Systems

Wednesday April 19, 14h 00m, *Synoptic Meteorology*, (Harland K. Saylor, Chairman):

(24) **Clement Todd**: Presentation to the Forecaster—A Bottleneck in Meteorology
(25) **Walter H. Hoecker, Jr.**: The Pressure Field of the Dallas Tornado
(26) **Edwin Kessler, III**: The Condensed Water Precipitated during Convection (presented by title)
(27) **J. K. Angell and D. H. Pack**: A Study of Vertical Oscillations of Tetroons Released from Wallops Island
(28) **S. K. Kao**: Trajectories and Diffusion of Particles in a Long Atmospheric Wave
(29) **William H. Klein, Billy M. Lewis, and Curtis W. Crockett**: The Interrelation between Daily and Mean Components in Objective Temperature Forecasts
(30) **Miles F. Harris, Frederick G. Finger, and Sidney Teweles**: Diurnal Variation of Wind, Pressure, and Temperature in the Troposphere and Stratosphere over the Azores
(31) **P. Putnins**: The Correlation between the Pressure Changes at the Surface and Aloft in the Greenland Area

Thursday, April 20, 09h 00m, *Atmospheric Physics* (Charles A. Palmer, Jr., Chairman):

(32) **B. B. Phillips and William E. Cobb**: Benchmark Measurements of Atmospheric Electric Variables at Mauna Loa, Hawaii
(33) **M. Brook, N. Kitagawa, and E. J. Workman**: The Effectiveness of Continuous Currents vs. Return Strokes in Lowering Charge to Earth
(34) **N. Kitagawa and M. Brook**: Electron Disappearance Processes in the Lightning Channel
(35) **James E. McDonald**: Role of Natural Silicaceous Dusts in Ice Nucleation
(36) **Thomas E. Hoffer**: A Laboratory Investigation of Droplet Freezing Insoluble Nuclei
(37) **Jesse B. Havard**: Radiational Characteristics of Water Clouds at Infrared Wave Lengths
(38) **J. T. Houghton and Walter Hitschfeld**: Radiative Transfer in the Lower Stratosphere Caused by the 9-6-Micron Band of Ozone
(39) **M. H. Wilkening and Minoru Kawano**: The Effects of Thunderstorms on the Radon-Daughter Ion Content of the Atmosphere
(40) **M. Kawano and M. H. Wilkening**: Some Characteristics of Radon-Daughter Ions in the Atmosphere

Thursday, April 20, 14h 00m, *Cyclic Exchange of Soluble and Insoluble Materials Between the Earth and Atmosphere* (Lester Machta, Chairman), cosponsored with Sections of Oceanography, of Volcanology, Petrology, and Geochemistry, and of Hydrology.

(41) **Wallace Broecker**: Carbon Dioxide Exchange Between Ocean and Atmosphere
(42) **D. C. Blanchard**: The Cyclic Exchange of Sea-Salt and Organic Material Between the World Ocean and the Atmosphere
(43) **A. H. Woodcock**: Magna-Sea-Air Contact Areas as Sources of Sea-Salt Particles in the Atmosphere
(44) **Walter B. Langbein**: Salinity of Closed Basins
(45) **Sean A. Twomey**: On the Addition of Salt to the Air from Land Surface
(46) **Irving Friedman**: Deuterium in the Atmosphere

Friday, April 21, 09h 00m, *Cyclic Exchange of Soluble and Insoluble Materials Between the Earth and Atmosphere*, continued (James P. Lodge, Chairman):

(47) **Christian E. Junge and Charles W. Chagnon**: A World-Wide Stratospheric Aerosol Layer
(48) **Victor H. Regener**: Ozone in the troposphere
(49) **James G. Moore**: Determination of the Vertical Distribution of Ozone by Satellite Photometry

A round table discussion on Continental Hazes followed.

Friday, April 21, 09h 00m, Great Hall, National Academy of Sciences, *High Atmosphere* (Gerhard F. Schilling, Chairman): cosponsored with Section on Geomagnetism and Aeronomy:

(50) **S. Matsushita** (University of Colorado): Lunar Tidal Variations in the Ionophere
(51) **B. Haurwitz** (University of Colorado): Periodic Winds in the Upper Mesosphere
(52) **Sydney Chapman** (University of Alaska): Lunar Effects and Winds

(53) R. R. Rapp (The RAND Corp.): Wind and Temperature in the Mesosphere
(54) F. E. Roach (National Bureau of Standards: Auroral Arcs in Mid-Latitudes
(55) E. P. Ney (University of Minnesota); Corpuscular Radiation and Meteorology

Friday, April 21, 1961, 14h 00m, *Research—Current and Future* (F. W. Reichelderfer, Chairman):

(56) Josh Holland (Atomic Energy Commission, Washington, D. C.): Opportunities and Obstacles in Atmospheric Research
(57) D. P. McIntyre (Meteorological Service of Canada, Toronto, Canada): Meteorological Research in Canada
(58) Earl G. Droessler (Atmospheric Sciences Program, National Science Foundation, Washington, D. C.): Atmospheric Sciences in the National Science Foundation
(59) Walter Orr Roberts (University Corporation for Atmospheric Research, Boulder, Colo.): The National Center of Atmospheric Research—A Progress Report
(60) Henry G. Houghton (Department of Meteorology, M.I.T., Cambridge, Mass.): Plans and Programs for Geophysical Research at M.I.T.
(61) Robert M. White (The Travelers Research Center, Inc., Hartford, Conn.): Meteorological Research at The Travelers Research Center, Inc.
(62) Harry Wexler (Office of Meteorological Research, U. S. Weather Bureau, Washington, D. C.): Program and Plans for Meteorological Research in the U. S. Weather Bureau

Woodrow C. Jacobs, *Secretary*

APPENDIX E—Minutes of the Annual Meeting of 1961, Section of Geomagnetism and Aeronomy

The Forty-Second Annual Meeting of the Section of Geomagnetism and Aeronomy was called to order by President Leroy R. Alldredge at 09h 00m, Tuesday, April 18, 1961, in The Great Hall, National Academy of Sciences. A short business meeting constituted the first part of the session. Announcement was made of the Section officers elected recently to serve through the next triennium: C. T. Elvey, President; E. H. Vestine, Vice President; J. H. Nelson, Secretary. Membership in the several committees of the Section was reviewed. President Alldredge expressed thanks for the assistance given to the Executive Committee during the current administration.

David G. Knapp was appointed Chairman of the Resolutions Committee.

Following the business session papers were presented as listed below, the speakers being designated by an asterisk:

(1) Bob J. Patton* and John L. Fitch: Anhysteretic Remanent Magnetization in Small Steady Fields
(2) Walter Hays*, R. Ernest Anderson, and Leroy Scharon: The Influence of Remanent Magnetism on Magnetic Intensity Data
(3) Isidore Zietz* and Kenneth G. Books: Aeromagnetic Interpretation and Remanent Magnetization
(4) Z. F. Danes*: The Sudden Impulse of August 25, 1958
(5) Naoshi Fukushima*: Persistent Disturbance in the Polar Regions on Geomagnetically Quiet Days
(6) W. B. Chadwick*: Variation of Sporadic E with Sunspot Number, 1949–1959
(7) Wallace B. Murcray*: Infra Red Emission and Absorption Spectra of the Atmosphere at College, Alaska

The second session (Tuesday afternoon) was called to order by President Alldredge at 14h 00m. Past President H. R. Joesting relieved Dr. Alldredge as chairman of the meeting at 15h 45m. The following papers were presented:

(8) George Hopkins, Jr.*, F. U. Williams, and C. E. McCullough: An Investigation of the Surface Distribution of Earth Current Activity
(9) Alfred J. Zmuda*: The Variation of Harmonic Coefficients
(10) Louis Hurwitz*: Tests of Schuster's Method for the Spherical Harmonic Analysis of the Geomagnetic Field
(11) Sanker Narayan and G. P. Woollard: An Evaluation of the Absolute Reliability of the Proton Nuclear Precession Magnetometer (Paper read by Dr. Meyer.)
(12) N. F. Ness*, T. L. Skillman, C. S. Scearce, and J. P. Heppner: Rocket Borne Rubidium Vapor Magnetometer Measurements
(13) John M. Kelso*, Paul J. Coleman, Jr., and Robert R. Morgan: A Magnetic Coil Facility for Space Vehicle Testing and Calibration
(14) Edwin J. Chernosky: The Variable-Area Technique for Obtaining Magnetic Data

(15) **H. Freeborn Johnston**: Thesaurus of Annual Magnetic Values at World Geomagnetic Observatories

The second and last individual session of the Section adjourned at about 16h 30m. A short period of discussion, including questions and answers, followed most of the papers. Attendance at the sessions varied between 60 and 120.

Separate reports are given of the joint sessions with Planetary Sciences Committee, with Meteorology, and with Tectonophysics.

J. Hugh Nelson, *Secretary*

APPENDIX F—Minutes of the Annual Meeting of 1961, Section of Oceanography

The business meeting of the Section of Oceanography was called to order by Vice President Pritchard, at 09h 15m on Wednesday, April 19, 1961, in the Great Hall at the National Academy of Sciences.

The results of the election of new officers for the Section were reported as follows:

President: Donald W. Pritchard
Vice President: Robert S. Arthur
Secretary: Arthur E. Maxwell

Bruce Heezen reported that the Section's Committee on matters dealing with the proposed International Association of Quaternary Research is making plans to participate in a proposed meeting to be held in Poland in 1965.

In the absence of the Chairman, John Lyman, Vice President Pritchard gave a preliminary report on the Section's Committee on AGU Publications, and other related matters. The Committee pointed out that although the per cent of Oceanographic papers now appearing in the Journal of Geophysical Research is less than half of that published in the older AGU Transactions, the total number of pages has almost tripled. Results of a questionnaire sent out to a limited number of oceanographic members showed that a majority so polled expressed dissatisfaction with the *Journal*, but there was no clear agreement as to how it could be improved.

The Business Meeting was then adjourned, and the scientific sessions opened.

The following papers were then presented at this session:

(1) **June G. Pattullo**: Seasonal Variations in Heat Storage in the Pacific Ocean during the IGY
(2) **Rhodes W. Fairbridge and Oswald A. Krebs, Jr.**: Sea Level and the Southern Oscillation
(3) **Ferris Webster**: The Kinetic Energy Balance of Gulf Stream Meanders
(4) **Frank Chew**: On the Transverse Component of the Florida Current off Miami
(5) **John D. Cochrane**: Some Observations of Mass Field and Surface Flow in the Yucatan Current
(6) **Frank Chew and K. L. Drennan**: On the Eastward Flow of the Mississippi River Discharge
(7) **Guy A. Franceschini**: Water Balance of the Gulf of Mexico
(8) **D. Q. Wark, R. W. Popham, W. A. Dotson, and K. S. Colaw**: Simultaneous Observations of Ice from Aircraft and Tiros II

Wednesday, April 19, 1961, 14h 00m, Great Hall, National Academy of Sciences:

(9) **William H. Tolbert and Garrett G. Salsman**: On the Nearshore Microtopography of the Sea Bottom Adjacent to Panama City, Florida
(10) **Marshall Schalk**: Sea-Ice Movement of Beach Material in Vicinity of Point Barrow, Alaska
(11) **George B. Dowling**: The Bathyconductograph; a New Oceanographic Tool
(12) **George B. Austin**: Navigation Reference Markers with Applications to Near-Shore Oceanographic Investigations
(13) **C. L. Buchanan**: Reaction of Electronic Components to a High-Pressure Environment
(14) **A. Conrad Neumann and David A. McGill**: Circulation of the Red Sea in Early Summer
(15) **James H. Carpenter and E. Dixon Stroup**: Circulation Patterns in a Tributary Estuarine Embayment
(16) **Georg Wüst**: On the Vertical Circulation of the Mediterranean Sea

Thursday, April 20, 1961, 09h 00m, Great Hall, National Academy of Sciences:

(17) **Eugene C. LaFond**: Oceanography in Southeastern Asia
(18) **Roy D. Gaul**: The Travel of Internal Temperature Fluctuations at Texas Tower No. 4
(19) **Blair Kinsman**: Some Evidence on the Effect of Non-Linearity on the Position of the Equilibrium Range in Wind-Wave Spectra
(20) **Allen H. Schooley**: Mean Roughness Factor as a Function of Wind Velocity
(21) **J. E. Chappelear**: Shallow-Water Waves
(22) **Eugene C. LaFond**: Convergences and Divergences in the Near-Surface Layers of the Sea

(23) William H. Tolbert and Garrett G. Salsman: Marine Life off Panama City, Florida

(24) Irving I. Schell: Remarks on Some of the Iceberg Severity off Newfoundland and Its Implications

Thursday, April 20, 14h 00m, and Friday, April 21, 09h 00m; Auditorium, D. C. Chapter, American Red Cross; cosponsored with Sections of Meteorology, of Volcanology, Geochemistry, and Petrology, and of Hydrology. Symposium: *Cyclic Exchange of Soluble and Insoluble Materials between the Earth and the Atmosphere.* (See papers 41 through 49 under Appendix D—Section of Meteorology).

E. C. LaFond, *Secretary*

APPENDIX G—Minutes of the Annual Meeting of 1961, Section of Volcanology, Geochemistry, and Petrology

The business meeting was called to order at 14h 00m, Wednesday, April 19, by President A. O. Nier.

The President announced that the officers of the Section for the three years beginning July 1, 1961 are,

President: Hatten S. Yoder
Vice President: Edward Goldberg
Secretary: David Wones

An announcement was made of the Symposium on *Ignimbrites and Hyaloclastites* to be held by the International Association of Volcanology, in Catania, Sicily September 15 to 24. The forms for registration can be obtained from I. Friedman, United States Geological Survey, Washington 25, D. C., and must be returned to the General Secretary of the IAV by June 15, 1961.

The Science Council of Japan is organizing symposia on *Prediction of Time and Place of Volcanic Eruption* and on *Relation Between Magmas and Nature of Volcanic Eruption,* to be held in Japan during May and June, 1962. Details will be announced later.

Frank Schairer discussed the progress made in Helsinki and in Copenhagen to secure geochemists a place in international meetings. An *ad hoc* committee of geochemists and volcanologists was organized in Helsinki and delegated by the IUGG to plan a program in geochemistry for the next IUGG triennial meeting in Berkeley, California, in 1963. The committee was also directed to meet with the International Union of Pure and Applied Chemistry, and the International Geological Congress to investigate the future role of geochemistry in the various international meetings.

The section held joint meetings with the Sections of Hydrology, Meteorology and Oceanography, during which a symposium on *Cyclic Exchange of Soluble and Insoluble Materials between Earth and Atmosphere* was presented.

The following papers were presented at the scientific sessions. All meetings were held in the Auditorium, General Services Building, except as otherwise noted.

Tuesday, April 18, 14h 00m.:

(1) Heinz Stauffer: Cosmogenic Rare Gases in Stone Meteorites

(2) V. Rama Murthy: Isotopic Composition of Silver in Iron Meteorites

(3) R. K. Wanless, C. H. Smith, W. D. Loveridge, and J. A. Maxwell: Magnesium Isotopic Variations in Nature

(4) A. C. Daughtry, Douglas Perry, and Milton Williams: Isotopic Composition of Magnesium in Sediments

(5) Roy S. Clarke, Jr., and Maxwell K. Carron: Comparison of Tektite Specimens from Martha's Vineyard, Massachusetts, and Empire, Georgia

(6) W. H. Pinson and C. C. Schnetzler: Rb-Sr Correlation Studies of Tektites

(7) R. E. Folinsbee and L. A. Bayrock: The Bruderheim Meteorite (1)—Fall and Recovery

(8) F. A. Campbell and H. Baadsgaard: The Bruderheim Meteorite (2)—Chemistry and Mineralogy

(9) E. L. Fireman and J. DeFelice: Argon^{39}, Argon^{37}, and Tritium in the recently fallen Bruderheim Meteorite

(10) Alvin J. Cohen: Impact Crater Glasses; Systemization

Wednesday, April 19, 1961, 09h 00m:

(11) William Slawson and Carl F. Austin: Definition of a Geological Structure through Lead Isotopes

(12) R. M. Farquhar: Lead Isotope Abundance Variations among Galenas from the Keewatin Geological Province

(13) Bruce R. Doe: Lead Isotopes in Ore and Near-By Rocks near Balmat, N. Y.

(14) Stanley R. Hart: A Study of Mineral Ages in a Contact Metamorphic Zone

(15) William A. Bassett and Paul F. Kerr: Potassium-Argon Ages of Volcanics near Grants, New Mexico

(16) G. L. Davis, G. R. Tilton, and G. W. Wetherill: Ages of Minerals from Basement Rocks of the Southern Appalachian Region

(17) W. G. Deuser and L. F. Herzog: Rb-Sr Age Determinations of Muscovites and Biotites from Pegmatites of the Blue Ridge and Piedmont

(18) P. M. Hurley, H. Hughes, W. H. Pinson,

AND H. W. FAIRBAIRN: Argon Diffusion Coefficients in Micas at Low Temperatures Obtained from Alpine Fault Uplift in New Zealand

(19) JAMES C. COBB: Determination of Lead Isotopes by Alpha Activation Analysis

(20) JOHN A. S. ADAMS AND PAUL C. RAGLAND: Autoradiographic and Radiometric Screening of Samples for Absolute Age Determinations

Wednesday, April 19, 1961, 14h 00m:

(21) E. F. HEALD AND J. J. NAUGHTON: Homogeneous Equilibria in Volcanic Gases

(22) RAMA, M. KOIDE, AND E. D. GOLDBERG: Pb^{210} in the Hydrosphere

(23) H. CRAIG, Y. HORIBE, M. KOBAYAKAWA, AND L. I. GORDON: Isotopic Composition of Natural Water

(24) G. W. MOREY, R. O. FOURNIER, J. J. HEMLEY, AND J. J. ROWE: Silica in Thermal Waters of Yellowstone Park

(25) JAMES H. CROCKET AND JOHN W. WINCHESTER: Study of the Dilute Solid Solution of $ZnCO_3$ in $CaCO_3$ and Its Relevance to the Marine Geochemistry of Zn

(26) M. N. A. PETERSON AND EDWARD D. GOLDBERG: Feldspar Distributions in Deep-Sea Sediments

(27) JOHN E. NOAKES, A. F. ISBELL, AND DONALD W. HOOD: Conversion of Carbon Dioxide to Benzene for Liquid Scintillation Counting

(28) LEON T. SILVER: Major Gabbroic Magmatic Events and Geochronology

Thursday, April 20, 1961, 09h 00m:

(29) JULIAN GOLDSMITH, DONALD L. GRAF, AND JUANITA WITTERS: Studies in the System $CaCO_3$–$MgCO_3$–$FeCO_3$

(30) L. S. WALTER, P. J. WYLLIE, AND O. F. TUTTLE: Phase Relations in the System MgO–CO_2–H_2O

(31) F. W. DICKSON: The Pressure Coefficient of Solubility of Cinnabar in Solutions of the System HgS–Na_2S–H_2O at 50°C

(32) H. L. BARNES AND W. G. ERNST: Alkalinity in Hydrothermal Solutions

(33) J. F. SCHAIRER AND H. S. YODER, JR.: The System Nepheline–Forsterite–Silica and Its Relation to Crystallization of Basaltic Magmas

(34) H. S. YODER, JR. AND C. E. TILLEY: Derivation of Magma Types from a Primary Magma

(35) JOHN J. W. ROGERS: Variations in the Th/U Ratios in Granitic Rocks

(36) H. P. TAYLOR, JR., A. L. ALBEE, AND SAMUEL EPSTEIN: O^{18}/O^{16} Ratios of Coexisting Minerals in Three Mineral Assemblages of Kyanite-Zone Pelitic Schist

(37) CARL E. HEDGE: Sodium–Potassium Ratios in Muscovites as a Geothermometer

(38) T. N. IRVINE: Ultramafic Complex at Duke Island, Southeastern Alaska

Thursday, April 20, 14h 00m, and Friday, April 21, 09h 00m, Auditorium, D. C. Chapter, American Red Cross, *Cyclic Exchange of Soluble and Insoluble Materials between the Earth and the Atmosphere,* cosponsored with Sections of Meteorology, of Oceanography, and of Hydrology.

Friday, April 21, 14h 00m, General discussion of *Differentiation of the Upper Mantle and the Formation of the Crust,* cosponsored with the Section of Tectonophysics.

IRVING FRIEDMAN, *Secretary*

APPENDIX H—Minutes of the Annual Meeting of 1961, Section of Hydrology

President Langbein opened the business meeting at 09h 00m, Tuesday, April 18, 1961, in the Auditorium at the Department of State. He announced that AGU had taken action to reduce the present term of officers to two years in order to establish a new triennium period more in line with the timing of the General Assemblies of IUGG. The new officers will assume their positions for a regular three-year term starting July 1, 1961, and will have ample time to complete plans for the 1963 General Assembly.

The President announced the following slate of new officers for the Section of Hydrology: William C. Ackermann, President; David K. Todd, Vice-President; Ralph N. Wilson, Secretary.

President Langbein stated that the pressure of hydrologic activities at the international level was continuing to increase. The Section is continuing its activities in these affairs by participating in IUGG General Assemblies, and in symposia sponsored by the International Association of Hydrology and other international associations. He announced that more information concerning these matters would be presented later in the business meeting.

The matter of publishing hydrology papers in the *Journal of Geophysical Research* (JGR) was brought up by President Langbein. The AGU Council has authorized the publishing of an annual or a semiannual volume containing a collection of hydrology papers published previously in the JGR. The Section will select the papers to be included in this separate publication. This hydrology publication will be available at a nominal cost of $2.00 per year in addition to the regular AGU dues. The President urged that all hydrologists support this trial procedure by responding favorably to the announcement that will soon be published by AGU concerning this matter.

President Langbein announced that the Council of AGU had authorized the Russian Translation Board to undertake preparation of an English language journal on 'Soviet Hydrology'. If the request for funds is approved by NSF a board of hydrologists will select papers from five leading Soviet publications and will be responsible for the translations, under the jurisdiction of the Russian Translation Board. The proposed journal will be made available by AGU on a subscription basis, and would consist of about 750 pages a year.

The President announced that the Executive Committee of the Section of Hydrology would be asked to consider the establishment of new committees on Geochemistry of Water and on Hydrology of Soil Moisture. The increase of activities in these fields is believed to warrant the establishment of such committees in order to coordinate U. S. efforts in this connection. If adopted, it is planned that recommendations will be forwarded to the International Association of Hydrology, urging the establishment of similar committees in that organization.

In regard to relationship with the World Meteorological Organization (WMO), President Langbein stated that, because of the continued demand for additional uses of water, the UN had established under WMO a new Commission of Hydrological Meteorology (CHM), to consider the feasibility of enlarging the scope of that organization to include hydrologic matters. The interpretation of the terms of reference to the CHM currently are being considered at the first meeting of that organization. It is expected that a reasonable decision concerning hydrologic problems will be adopted by CHM for recommendation to WMO. It was announced that arrangements had been made for five of the foreign representatives attending this WMO meeting to present papers on our hydrology program.

President Langbein stated that the Federal Council for Science and Technology had established a *Panel on Hydrology* to investigate ways for upgrading the level of hydrology. The Panel, with President Langbein as Chairman, has developed a statement defining hydrology as an Earth science, and describing various aspects of the hydrologic cycle. Effort is being made to urge educational institutions to offer programs embodying a coherent and rational approach to the study of water. Activities of this Panel will be described occasionally in the AGU Transactions.

Vice-President Ackermann, Chairman of the Committee on Awards, announced that the paper 'Cyclic Flow of Salt Water in the Biscayne Aquifer of Southeastern Florida,' by F. A. Kohout, has been selected as the best hydrology paper to appear in the JGR during 1960. A certificate of the Horton Award was shown to Mr. Kohout and he was advised that it would be forwarded to him after the Officers had affixed their signatures.

R. N. Wilson, Secretary for International Participation, made the following announcements:

(1) Plans are complete for the Section to be represented at the Symposium on Ground Water Resources in Arid Regions to be held in Athens, Greece, October 10–21, 1961. This Symposium is being sponsored by IAH in collaboration with UNESCO. Approximately 15 U. S. hydrology papers will be presented at this meeting.

(2) Plans are underway for participation in the IAH Symposium on Land Erosion to be held in Bari, Italy, in 1962.

(3) The Section will participate in the IAH Symposium on Variations in the Regime of Existing Glaciers, scheduled for September 1962 in Obergurl, Austria.

(4) A considerable amount of work will be required to arrange a strong U. S. hydrology program for the 13th General Assembly of IUGG to be held in Berkeley, California, in 1963. Announcement regarding this General Assembly will be published in the AGU Transactions.

(5) Mrs. Ethel W. Coffay, of the Washington Office of the U. S. Geological Survey, has been designated as coordinator for the Section of Hydrology in handling U. S. matters related to the IAH Bulletin. Mrs. Coffay has been doing an outstanding job in securing U. S. subscriptions and advertisements for the Bulletin.

(6) The AGU has decided to hold a national meeting each year on the West coast in addition to the Annual Spring Meeting in Washington. The First Western National Meeting of AGU will be held at UCLA on December 27–29, 1961; the Section of Hydrology will appoint a Program Chairman to plan hydrologic activities for this annual meeting.

President Langbein expressed appreciation for the good efforts of Harry E. Schwarz, Program Chairman, in arranging an excellent program for our technical meeting.

The business meeting then adjourned and was followed immediately by the scientific sessions. The first session convened at 09h 30m, April 18, in the State Department Auditorium, under the chairmanship of President Langbein; about 75 members were present. The following papers were given (asterisk indicates speaker for joint paper):

(1) B. Harris*, A. L. Sharp, A. E. Gibbs and W. J. Owen: An Improved Statistical Model for Evaluating Parameters Affecting Water Yields of River Basins
(2) J. B. Stall*, and J. C. Neill: A Partial Duration Series for Low Flow Analyses
(3) W. M. Snyder: Some Possibilities for Multivariate Analysis in Hydrologic Studies
(4) A. L. Sharp*, W. J. Owen, and A. E. Gibbs: A Comparison of Methods for Estimating Precipitation on Watersheds

(5) Dah-Cheng Woo* and E. F. Brater: Laminar Flow in Rough Rectangular Channels
(6) B. M. Johnson, Jr.: An Application of the IBM 650 Computer to the Dimensionless Unit Hydrograph Method of Deriving Unit Hydrographs.
(7) K. G. Reinhart and A. R. Eschner*: Effect on Streamflow of Four Different Forest Practices in the Appalachian Mountains of West Virginia
(8) J. E. André and H. W. Anderson*: Variation of Soil Erodibility with Geology, Geographic Zone, Elevation, and Vegetation Type in Northern California Wildlands

The second session convened at 14h 00m, April 18, in the same auditorium, with W. E. Hiatt presiding. Mr. Hiatt introduced Dr. W. Friedrich of Germany, President of IAH, and Professor L. J. Tison of Belgium, General Secretary of IAH. The Chairman stated that the Section was honored and pleased to have these International Officers participating in our hydrology program. Approximately 115 people attended the session, at which the following papers were presented:

(9) J. Rodier: A New Method for Hydrologic Investigations in Arid Countries
(10) L. J. Tison: Local Scour in Rivers
(11) R. V. Keppel: Special Report on Storm of June 5, 1960 (Presented by J. E. Fletcher)
(12) R. Convit: Experience with Artificial Rainfall Stimulation in Venezuela (Presented by Roberto Cossio)
(13) J. E. Fletcher: Characteristics of Precipitation of the Southwest
(14) Uri Mané: Evaporation Data of Class A Pan as Indicator of the Yearly March of Evaporation from Larger Reservoirs
(15) P. R. Julian: A Study of Hydrometeorological Time-Series
(16) J. S. Sweet: Scientific Hydrology and Hydrologic Services in the USSR

The third session, part of a symposium on *Problems and Research in Sedimentation*, convened in the Reading Room, National Academy of Sciences, April 19, at 09h 00m, under the chairmanship of M. G. Wolman. The following program was presented (about 90 members and guests were present):

(17) F. J. Dragoun: Rainfall Energy as Related to Sediment Yield (Formal discussion by V. Vanoni, presented by W. S. Eisenlohr)
(18) J. R. McHenry* and L. L. McDowell: The Use of Radioactive Tracers in Sedimentation Research (formal discussion by Joe Lieberman)
(19) W. L. Moore* and F. D. Mash, Jr.: Experiments on the Scour Resistance of Cohesive Sediments (formal discussion by R. T. Martin)
(20) L. M. Brush, Jr.: Exploratory Study of Sediment Diffusion (Formal discussion by S. Corrsin)
(21) M. A. Melton: Methods for Measuring the Effect of Environmental Factors on Channel Properties (Formal discussion by D. L. Brakensiek was presented by B. Harris, after which Prof. Harris gave some of his own comments)

The second session of the symposium on *Problems and Research in Sedimentation* began on April 19 at 14h 00m, in the NAS Reading Room, under the chairmanship of M. G. Wolman. Approximately 65 persons attended. The following program was presented:

(22) A. R. Croft: Some Sediment and Erosional Phenomena Along the Wasatch Front (Formal discussion by D. D. Smith)
(23) C. E. Renn: Ecology and Fine Grained Sediments (Formal discussion by Ruth Patrick)
(24) E. R. Tinney: The Process of Channel Degradation (Formal discussion by Carl R. Miller)
(25) H. A. Einstein and R. B. Krone: Experiments to Determine Modes of Cohesive Sediment Transport in Salt Water (Presented by R. B. Krone)

The fifth general session convened at 14h 00m, April 19 in the Lecture Room, NAS, under the chairmanship of D. K. Todd. Approximately 60 people attended the session at which the following papers were presented:

(26) F. A. Kohout: Fluctuations of Ground-Water Levels Due to Dispersion of Salts
(27) T. D. Reynolds and E. F. Gloyna*: Permeability Measurements of Rock Salt
(28) L. C. Benz*, R. H. Mickelson, F. M. Sandoval and C. W. Carlston: Groundwater Investigations in a Saline Area of the Red River Valley, North Dakota
(29) L. K. Lau, W. J. Kaufman and D. K. Todd*: Dispersion in Radial Flow through Porous Media
(30) R. W. Nelson: In-Place Measurement of Permeability in Heterogeneous Media, II, Experimental and Computational Considerations
(31) M. S. Hantush: Flow of Ground Water in Sand of Non-uniform Thickness
(32) W. C. Walton* and W. H. Walker: Evaluating Wells and Aquifers with Analytical Methods
(33) J. E. Reed and M. S. Bedinger: Projecting the Effect of Changed Stream Stages on the Water Table
(34) H. R. Henry: Sea-Water Encroachment with Uniform Vertical Recharge

The sixth session, held in the State Department Auditorium, August 20, 09h 00m consisted of a symposium on *The Use of Tritium and Deuterium in Hydrology*. This session, under the chairmanship of C. W. Carlston, was attended by approximately 125 members. The following papers were presented:

(35) W. F. Libby: Tritium Geophysics
(36) R. M. Brown: Dispersal of Bomb Tritium in the Waters of the Ottawa Valley
(37) C. W. Carlston: Bomb Tritium in the Hydrologic Cycle
(38) L. L. Thatcher: Distribution of Tritium Rainout Following the 1958 Weapons Tests
(39) Lester Machta: Meteorological Interpretations of Tritium Measurements
(40) I. Friedman* and A. C. Redfield: Applications to Hydrology of Deuterium Variations in Natural Waters

The seventh, and final, session was hold in the State Department Auditorium at 09h 00m, April 21, with Vice President Ackermann presiding. Approximately 70 members were present. The following papers were presented:

(41) L. W. Swift, Jr.* and C. H. M. van Bavel: Mountain Topography and Solar Energy Available for Evapotranspiration
(42) J. B. Franzini: Progress Report—Evaporation Suppression Research
(43) W. J. Roberts: Reducing Transpiration from Plants
(44) K. R. Knoerr: Test of Models for Soil Moisture Depletion at Forest Sites in the Sierra Nevada
(45) T. J. Nordenson* and D. R. Baker: Weather Bureau Pan Evaporation Study
(46) J. R. Wallis: The Relation between Metal Cations and Soil Erodibility (Presented by Henry W. Anderson)
(47) J. Weertman: Mechanism for the Formation of Inner Moraines Found Near the Edge of Cold Ice Caps
(48) D. H. Miller: Folklore about Snowfall Interception (Presented by J. L. Smith)
(49) J. E. Fisher: Glacier Ogives of the Forbes Type
(50) A. J. West: Cold Air Drainage in Small Forest Openings (Presented by Henry W. Anderson)
(51) E. B. Shykind: Studies in Quantitative Geomorphology: Geomorphic Implications of the Dendritic Pattern

The meeting adjourned at 12h 20m.

Ralph N. Wilson, *Acting Secretary*

APPENDIX I—Minutes of the Annual Meeting of 1961, Section of Tectonophysics

President Hurley called the meeting to order at 09h 05m on April 21, in the auditorium of the General Services Administration building. The minutes of the previous meeting were approved. There being no other business to come before the group at this time, the session continued with presentation of papers. The asterisk indicates the speaker, for joint papers.

The following papers were given at the morning session:

(1) N. L. Carter*, J. M. Christie, and D. T. Griggs: Experimentally Produced Deformation Lamellae and Other Structures in Quartz Sand
(2) Hugh C. Heard: The Effect of Time on the Experimental Deformation of Rocks
(3) Kenneth L. Cook: The Problem of the 'Mantle-Crust Mix'-Lateral Inhomogeneity of the Uppermost Part of the Earth's Mantle.
(4) R. Ernest Anderson*, Walter Hays, and Wilford F. Weeks: Some Structural Aspects of the Missouri Precambrian
(5) John E. Sanders: Tectonophysics of Late Triassic Deformation
(6) Manik Talwani*, Bruce C. Heezen, and J. Lamar Worzel: Gravity Anomalies, Physiography, and Crustal Structure of the Mid-Atlantic Ridge
(7) George P. Woollard and Ned Ostenso: Crustal Structure in Antarctica
(8) John C. Behrendt: The Filchner Ice Shelf, Antarctica
(9) Melvin Friedman: Petrofabric Analysis of Experimentally Deformed Calcite-Cemented Sandstones

The afternoon session convened at 2h 05m. The following papers were presented as a symposium on *The Differentiation of the Mantle and the Formation of the Crust*, cosponsored with the Sections of Seismology, of Geomagnetism and Aeronomy, and of Volcanology, Geochemistry, and Petrology:

(10) William M. Adams: A Direct Method for Investigating the Interior of the Earth
(11) G. Faure* and P. M. Hurley: The Ratio Sr^{87}/Sr^{86} in Oceanic and Continental Basalts
(12) I. Kushiro and H. Kuno*: Origin of Basalt Magmas and Classification of Basaltic Rocks

Presentation of these papers was followed by prepared and informal discussions.

The session adjourned at 16h 55m.

P. M. Hurley, *Acting Secretary*

REPORT OF THE PLANNING COMMITTEE ON PLANETARY SCIENCES

HOMER E. NEWELL, *Chairman*

ROBERT JASTROW, *Secretary*

P. H. ABELSON
L. R. ALLDREDGE
J. W. CHAMBERLAIN
THOMAS GOLD
G. J. F. MACDONALD
HUGH ODISHAW
A. H. SHAPLEY
E. H. VESTINE
C. A. WHITTEN
HARRY WEXLER

Prefatory Note—The following proposal of the Planning Committee on Planetary Sciences was approved by the Executive Committee of the Council on March 25, 1961, but was held up by the Council as a whole, pending further deliberations. At the meeting of the Council on April 22 the following motion was unanimously approved by the Council.

Research in the planetary sciences has entered on a period of vigorous expansion in the past two years. The degree of expansion is indicated by a twenty-fold increase in the number of papers on the planetary sciences published in the *Journal of Geophysical Research* during the period from 1958 to 1960.

As interest develops in this area of research, it becomes increasingly evident that a formal unit must be established within the organized framework of scientific research in this country, to serve the interests of the ever increasing number of scientists participating in the United States' space program.

One year ago the President of the American Geophysical Union created the *ad hoc* Planning Committee on Planetary Sciences, in recognition of the coming need for the establishment of such an organizational unit. The Committee has participated in the arrangements for two national AGU meetings and one regional conference, as well in a jointly sponsored AGU-APS symposium at the last AAAS meeting. The experience accumulated by the Planetary Science Committee through these activities during the past year now provides a basis for considering effective means of future action in developing the potentialities of the Union for serving the interests of its membership in the planetary sciences. The very substantial total of 68 significant papers was contributed to the 1960 meeting, and 87 papers were presented at the 1961 meeting. All sessions at both meetings were attended by large audiences.

The discussion of modes for further development of AGU activity in the planetary sciences can best be discussed in the context of all organized United States activity in the physical sciences. Several alternatives exist within this broader statement of the question.

First, a new society might be formed, with members drawn from the existing national societies in the physical sciences, and with a program devoted exclusively to planetary and space research. Such a society would provide the advantage of a clearly recognized home for the space sciences. On the other hand, a new society would have to draw on the scientific community for the financing of its activities and the staffing of its organization. This responsibility must be added to the burden of operating the established societies, which already constitutes an alarmingly severe drain on the energies of scientists, and a serious interference with their research. Furthermore, the creation of a new society would increase the repetition of programs in national meetings and symposia, whereas the prime objective should be the reduction of the present degree of repetition. It is certain that the major existing societies will not suppress their interest in this area of research in deference to a new society; its formation would, therefore, add still other national meetings on space research to the large number now commonly arranged each year.

A second possibility is the establishment of a Joint Planetary Science Commission among the societies with interests in this area. These would include the American Geophysical Union, the American Physical Society, the American Astronomical Society, and the U. S. National Committee for URSI. The establishment of a joint commission would provide coordination of program activities, and a broad basis of support in the scientific community. On the other hand, it would provide no real home for the planetary and space sciences unless the individual societies were to provide full support through the creation of formal units within their separate structures. Without this backup from planetary and space science sections in each society, the joint commission would necessarily be an ineffective structure with ambiguous responsibilities. In that case the apparent advantage of a broad base of participation would be only illusory.

A third possibility is the continuation of the existing committee. This alternative has the advantage that it serves to draw attention to the planetary sciences, while eliminating the necessity for extensive organizational changes. Furthermore, the Committee could continue to draw on existing sections of the AGU for assistance and support. The continuation of the Committee in its present form would carry the disadvantage, in our view, that it would not give the full attention to the planetary sciences that they deserve in view of their growing importance in the Earth sciences. The organizational status of a committee is weaker than that of the regularly constituted AGU sections, and this difference would appear to place the planetary sciences in a secondary position with respect to the other fields of research incorporated in the AGU. By virtue of its secondary status the Committee could not be fully effective in drawing more support from the scientific community for research in this area, nor could it suitably play its passive role in reflecting the existing interests of scientists in this field.

The fourth possibility is to establish a new section within the AGU, devoted to the planetary sciences, which we define as research investigations related to the Moon and the planets, and their atmospheres. We believe that research conducted in the planetary sciences has developed within the last two years into a major area of the Earth sciences. It is an area the importance of which is comparable to that of the existing disciplines in this field which are now represented by Sections in the American Geophysical Union.

It is recognized by the Committee that a substantial overlap exists between this area of research, as so defined, and the areas covered by several of the existing Sections. However, it must be pointed out that a substantial amount of overlap now occurs among several of the existing Sections. The value of their separate existence is not questioned because it is clear in each case that the common denominator of research experience and training differs substantially from Section to Section. For example, important areas of research are shared by the meteorologists and the upper atmosphere physicists, and joint symposia and meetings have been arranged occasionally with great profit to both groups. Yet it is clear their professional motivations and viewpoints are distinct. In the same manner we consider it clear that a community of experimental and theoretical interests draws together those members of the AGU who are engaged in the development of space flight experiments related to lunar, planetary, and atmospheric investigations. Their unity as a professional group is established by their common interest in the experimental problems of space flight instrumentation, and in the interpretation of the data received.

Since this segment of the AGU membership exists *de facto* as a professional group, it is appropriate to consider the recognition of the group by the formation of a new AGU section. The research interests of this section will indeed overlap those of other sections, and joint programs and symposia can be arranged with great profit in the future, as have been arranged in the past between the Planetary Science Committee and the Section of Geomagnetism and Aeronomy.

It may be noted that, up to the present time, the formation of a section on planetary science would have been a premature action, for until now the professional group in planetary research has been only nascent. Now, with the great volume of research that has developed in this area during 1960, and the establishment of well-defined patterns of research in the planetary sciences, the existence of a professional planetary science group is established as a manifest fact, so that, whereas the formation of an AGU section on planetary science would have been a premature action at an earlier date, we believe that the AGU will now be derelict in its obligations to its membership if it fails to take such action in 1961.

It is, therefore, the sense of the Committee that the formation of a Section of Planetary Science must be considered by the Executive Council of the Union as an action to be recommended to its membership for implementation by the end of 1961.

The establishment of a Section of Planetary Science within the American Geophysical Union will also provide a correspondent on a national basis to the IUGG's interest in planetary science.

At the same time, it behooves the American Geophysical Union to take the initiative in encouraging other U. S. national societies to establish similar sections for those of their members who are engaged in planetary and space research. The American Astronomical Society, the American Physical society, and the U. S. National Committee for URSI, together with the AGU, represent the professional groups with the strongest participation in this field. The claim of the American Astronomical Society to an interest in the Moon and the planets is as legitimate as that of the AGU. The American Physical Society may be expected to develop an interest comparable to that of the AGU, in Sun-Earth relationships and the physics of the interplanetary plasma. Finally, the U. S. National Committee for URSI has been active in the arrangement of meetings and symposia related to the physics of the ionosphere and other areas of space research. The encouragement of the APS, the AAS, and URSI to recognize the interest of their members in these fields of research will be an important contribution on the part of the AGU toward the development of space science in the United States.

However, we note that the American Geophysical Union must assume primary responsibility, with the other societies, in sponsorship of planetary and space research in the United States. We adopt this view regarding primacy of the American Geophysical Union on the basis of (1) the leading position taken by the *Journal of Geophysical Research* in the publication of planetary sciences papers, and (2) the strong support given by the AGU membership to the Planetary Science Committee, in the programs arranged by the Committee at national meetings.

On the basis of these remarks the Committee recommends the following actions as best serving the interests of the American Geophysical Union membership and the United States scientific community participating in the planetary and space sciences program:

First, that the organizational status of planetary sciences in the American Geophysical Union be reinforced by the establishment of a new Section on Planetary Science. This section will work in close cooperation with other AGU Sections in the arrangements of meetings, symposia and other activities.

Second, that the President of the American Geophysical Union write to the Presidents of the American Physical Society and the American Astronomical Society, and to the Chairman of the U. S. National Committee for URSI, to propose the establishment of parallel sections in planetary or space research within those organizations. This step will constitute the recognition of the fact that the problems and techniques of planetary and space research are drawn from all of astronomy, physics, and the Earth sciences.

Third, that the Council of the American Geophysical Union recommend to the Space Science Board of the National Academy of Sciences that a joint Commission on Space and Planetary Sciences be established whose members will represent the American Geophysical Union, the American Physical Society, the American Astronomical Society, and the United States National Committee for URSI.

Miscellaneous Items

Pacific Northwest Regional Committee

The newly elected officers and representatives of the Pacific Northwest Regional Committee for 1961-1964 are: Chairman—Robert Beaumont; Secretary-Treasurer—Hollis Orem; Representatives—Fred Natella (Geodesy); Robert de Luccia (Seismology and Tectonophysics); Robert Beaumont and Fred Decker (Meteorology); Keith E. Anderson (Geomagnetism and Aeronomy, and Volcanology, Geochemistry, and Petrology); Robert Paquette (Oceanography); Charles L. Barker, Hollis Orem, and Meredith Thoms (Hydrology).

The Committee met at Portland, Oregon, on March 13, 1961. The 1961 Annual Pacific Northwest Regional Meeting has been set for October 31-November 1. An evening banquet is planned. It was suggested that the 1962 Annual Meeting be held in Seattle, and the 1963 meeting in Pullman, Washington.

Advantages of a joint meeting with some other group were discussed. A proposed program featuring oceanography was unanimously favored. Several other fields of interest were also considered for future meetings.

It was noted that the First National Western Meeting of AGU will be held in Los Angeles during the last week in 1961, and that this may cause some conflict among potential contributors to the Pacific Northwest Regional Meeting.

Geophysical Society of Hawaii

At a meeting held in Honolulu on February 14, 1961, Dwight B. Kline of the U. S. Weather Bureau, Washington, D. C., spoke on 'The freezing nuclei and rainfall singularity problem.'

The Society and the Hawaiian Academy of Science jointly sponsored a talk by Dr. Hisashi Kuno of the Geological Institute, University of Tokyo, on February 28, at the University of Hawaii. Dr. Kuno, an outstanding student of both recent and ancient volcanoes, spoke on 'Volcanoes in Japan.' He is a visiting International Scientist under a program of the American Geological Institute and the National Science Foundation.

Meeting to Support Science Education Program

The AGU was one of eight scientific organizations that sent representatives to a meeting held on November 3, 1960 at the National Education Association (NEA) headquarters for the purpose of considering ways to obtain financial support for the "Future Scientists of America" program. Started in 1951 by the American Society of Metals, the program grew rapidly. In 1960 the National Science Teachers Association of NEA, took it over. Continued growth has made it necessary to solicit financial support from the scientific societies of America. The meeting of November 3, and subsequent meetings held in New York and Boston, by a special committee were directed to obtain the necessary support for this important program. Malcolm Rigby represented the AGU at the Washington meeting.

AMERICAN GEOPHYSICAL UNION

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

Statutes and By Laws

(Originally adopted at organization in 1919 and as amended to September 30, 1960)

PREAMBLE

The American Geophysical Union is hereby established by the National Research Council. The Council of the American Geophysical Union is the United States National Committee of the International Union of Geodesy and Geophysics, and the Committee on Geophysics of the National Research Council.

STATUTES

Article 1: Objects—(a) To assist in carrying out the objects of the International Union of Geodesy and Geophysics, which are: To promote the study of problems concerned with the figure and physics of the Earth; to initiate and coordinate researches which depend upon international cooperation, and to provide for their scientific discussion and publication; and to facilitate special researches.

(b) To promote, coordinate, and facilitate the study of the various branches and interrelationships of geodesy and geophysics in the United States of America, its outlying territories, and the ocean; to provide for scientific discussion, publication, and dissemination of information relative to these fields through its publications.

Article 2: Bequests, Grants, Contributions, and Funds—The Union, upon approval of the National Research Council, may receive bequests, grants, contributions, and funds and may make disbursements therefrom, upon approval of the National Research Council.

Article 3: Membership—The membership of the American Geophysical Union shall be as follows:

(a) *Members*—(1) Those who composed the membership of the 'American Section of the proposed International Geophysical Union' on July 1, 1919. (2) Citizens of the United States of America engaged in geophysical research or its applications, elected by the Council of the American Geophysical Union. (3) Nationals of other countries having the same qualifications, elected by the Council of the Union; these may not vote or be officers of the Union or of its Sections, or delegates of the Union to International Assemblies or Meetings.

Members in good standing for a total of 25 years (or 15 years for members joining before January 1, 1946) shall, following retirement from active professional service because of age or disability and upon written notice to the General Secretary, be extended the complete privileges of membership without further payment of dues. The Council may also extend these privileges to members for extraordinary services to the Union.

(b) *Members ex officio*—The President of the National Academy of Sciences and the Chairman of the National Research Council.

(c) *Corresponding Members*—Nationals of other countries, outstanding in the field of geophysics, elected by the Council of the American Geophysical Union; they shall not pay dues but shall enjoy the privileges of Members except that they may not vote or be officers of the Union or of its Sections or delegates of the Union at International Assemblies or Meetings.

(d) *Associates*—(1) Citizens of the United States of America other than those eligible for regular membership under Article 3, Sections (a) or (b), whose interest in Geophysics is deemed by the Council of the Union to warrant their election. Associates shall enjoy the privileges of Members except that they may not be officers of the Union or of the Sections, or be delegates of the Union at International Assemblies or Meetings. (2) Nationals of other countries having the same qualifications, elected by the Council of the American Geophysical Union; these may not vote or be officers of the Union or of its Sections, or delegates of the Union to International Assemblies or Meetings.

(e) *Corporation Members*—Corporations and other organizations interested in geophysics, elected by the Council of the Union. The designated representative of each such organization shall enjoy the privileges of a Member.

(f) *Student Members*—College and university students elected by the Council. A certificate signed by an officer or professor of the institution attended shall be submitted annually as qualification. The classification of a student member shall terminate after one year of non-student status, and if judged to be qualified by the Council, the former student shall be an Associate Member on his own writtten acceptance. Student members shall be privileged to participate in scientific meetings and receive the *Transactions* of the Union.

(g) *Supporting members*—Corporations, other

(i) Planetary Sciences

organizations, and individuals interested in geophysics and desirous of supporting the Union may become members under the following classifications upon election by the Council of the Union and payment of the annual sums indicated: Contributing Members, $500; Sustaining Members, $1000; Benefactors, $5000. Each Supporting Memmer and the designated representative of the corporation or other organization Supporting Member shall enjoy the privileges of a Member.

Article 4: Sections—The American Geophysical Union shall consist of Sections as follows: (a) Geodesy; (b) Seismology; (c) Meteorology; (d) Geomagnetism and Aeronomy; (e) Oceanography; (f) Volcanology, Geochemistry, and Petrology; (g) Hydrology; (h) Tectonophysics.

Members, Corresponding Members, Associates, and Corporation Members shall designate the Section, or Sections, with which they desire to be affiliated. The function of the Sections, in their respective fields, shall be the promotion of the objects of the American Geophysical Union.

Article 5: Officers of the American Geophysical Union—The officers of the American Geophysical Union shall consist of a President, a Vice President, and a General Secretary, whose terms of office shall expire June 30, 1961. Thereafter terms of office shall ordinarily be for periods of three years. Elections of officers shall take place, by mail ballot, in the autumn or winter following a General Assembly of the International Union of Geodesy and Geophysics, and in the case of a shift from the current triennial series of General Assemblies, the Council may provide for an appropriate shift in the schedule for election of officers of the American Geophysical Union. The President and the Vice President shall not be eligible for immediate reelection. In case any office, except that of President, becomes vacant, the Council of the Union shall designate a successor to complete the term. In the case of the death or resignation of the President, the Vice President shall automatically become President.

There may also be elected, by mail ballot, an Honorary President whose nomination shall be tentatively approved at a meeting of the Council, followed by a mail ballot of the entire Council. A confirming vote of three-fourths of those voting shall be required to place the name on the ballot. This office shall be filled only as a special honor for outstanding service to the Union. It shall be for life without payment of dues.

The General Secretary shall act also as Treasurer and shall receive and disburse all dues, grants, and funds otherwise received as authorized by the Council of the Union; his accounts shall be audited annually by a Committee on Audit.

A Secretary for International Participation shall be appointed by the President of the American Geophysical Union with the advice of the Council for an initial term of six years with eligibility for reappointment. This officer shall be responsible for planning and organizing AGU participation in appropriate international activities, cooperation with Sections in the international aspects of their programs, and serve as chairman of the Committee on International Participation.

The Council of the Union may employ an Executive Secretary, who shall be directly responsible to the General Secretary.

Article 6: Officers of Sections—The officers of each Section of the American Geophysical Union shall consist of a President, a Vice President, and a Secretary, whose eligibility and periods of office shall correspond to those of the Union as indicated under Article 5. These officers shall be elected by mail ballot. In case any office becomes vacant the Executive Committee of the Section concerned shall designate a successor in office to complete the term. The President of each Section shall have the power to appoint, with the right to vote, a representative of the Section to such meetings of the Council of the Union as he may be unable to attend.

Article 7: Council—The Council of the American Geophysical Union shall consist of the President, the Vice President, the General Secretary, the retiring President, and the Secretary for International Participation of the Union; the President or his designated representative of each Section of the Union; a qualified geophysical scientist nominated by each of the following four government agencies: the Department of Defense, the Department of the Interior, the Department of Commerce, and the National Science Foundation; the Foreign Secretary of the National Academy of Sciences; the Chairman of the Section of Geophysics of the National Academy of Sciences or a duly designated representative; the Chairman of the Division of Earth Sciences of the National Research Council or a duly designated representative; three members at large nominated by the Section on Geophysics of the National Academy of Sciences; and Officers of the International Union of Geodesy and Geophysics who are citizens and residents of the United States. The Executive Secretary of the Union shall serve as secretary of the Council with voice but without vote. Non-members of the AGU on the Council shall exercise neither voice nor vote on domestic or fiscal matters of the Union. All appointments to the Council shall be in effect for the same periods as the terms of the elected officers of the American Geophysical Union.

This Council shall have charge of all administrative matters of the American Geophysical Union and shall be the representative of the Union in its relations with the National Research Council and the International Union of Geodesy and Geophysics. It shall have the power to delegate to the Officers and to standing and special committees, with power of action and decision, any of its specific functions.

There shall be an Executive Committee of each of the Sections of the Union which shall include at least the President, Vice President, and the Secretary and the last past President of the Section.

Article 8: Annual Meetings—The American Geophysical Union and its Sections shall meet annually at such time and place as may be chosen by the Council of the Union.

Article 9: Special Meetings—Special Meetings of the American Geophysical Union, of any Section or of any group of Sections, and of any Local or Regional Branch may be called by the respective Presidents with the advice of the respective Executive Committees; notification of such meetings must be communicated promptly to the office of the General Secretary of the Union.

Article 10: Branches of the Union—Local or Regional Branches of the Union may be established on the approval of the Council of the Union. These Branches shall be organized along the general lines of the Union, shall be responsible to the Council of the Union, and shall duly report their activities through the General Secretary.

Article 11: Publications—The official publications of the Union shall include the *Transactions of the American Geophysical Union, Journal of Geophysical Research*, and the *Geophysical Monograph Series*, published under the auspices of the National Academy of Sciences—National Research Council.

The *Transactions* shall be a regular periodical which contains the reports of Union activities, notes and personalia, special announcements, and other material of a transitory or semi-popular nature. Control of matter to be published in the *Transactions* shall rest in the Executive Secretary with the aid and counsel of the Secretaries of the several Sections.

Journal of Geophysical Research shall be a regular periodical which contains the scientific and technological papers and related departments. Control of matter published in *Journal of Geophysical Research* shall rest in the Editors-in-Chief appointed for indefinite terms by the Council, and shall have the aid and counsel of an advisory board representing the special fields of geophysics. This board shall be designated by the President in consultation with the Editors-in-Chief and the Council.

The *Geophysical Monograph Series* will be published as members of the series develop and issues of the series shall be under the control of a special editorial board designated by the President, with the Executive Secretary serving as managing editor of the series.

Other publications that may develop shall be subject to approval by the Council under plans developed for their editorial management.

Non-members of the Union may subscribe to the *Transactions*, and purchase individual copies thereof, as well as other publications of the Union, at rates approved by the Council of the Union.

Article 12: By Laws—The American Geophysical Union is authorized to enact such By Laws as may be necessary for the performance of its functions and duties.

Article 13: Amendments—(a) Any Member, Associate, or Corporation Member may propose an amendment to the Statutes. Such proposals shall be considered by the Committee on Statutes and By Laws and presented to the Council of the Union with recommendations. Upon approval of the Council, proposed amendments shall be submitted to the membership for a mail vote. Balloting shall be open for not less than 30 days. A majority of the votes cast shall be required for adoption. Amendments shall be subject to the approval of the National Research Council.

(b) Any Member, Associate, or Corporation Member may propose an amendment to the By Laws. Such proposal shall be considered by the Committee on Statutes and By Laws and presented to the Council of the Union with recommendations. Upon approval of the Council, proposed amendments shall be published in the *Transactions* not less than 30 days prior to action at a succeeding meeting of the Council. Action must be completed within a year after publication. Approval by the Council at this meeting shall constitute adoption of the amendments. An affirmative vote of not less than half the membership of the Council shall be required for approval.

BY LAWS

(1) The *fiscal year* of the American Geophysical Union shall conform to the calendar year.

(2) Members of the Union, in classes (a) and (d) of Article 3 of the Statutes, shall pay dues, the amount for each year to be fixed by the Council of the Union. Members of class (e) shall pay dues of not less than $100 for each calendar year. Any Member or Associate, on payment of an amount to be fixed by the Council of the Union (currently $200.), shall be relieved of further payment of dues. Members of class (f) shall pay dues approximating the cost of a volume of the *Transactions* plus the cost of a volume of the *Journal of Geophysical Research*, the amount for each year to fixed by the Council.

(3) *Standing Committees* shall be as follows: Statutes and By Laws; Membership; Meetings; Nominations; Budget; Audit.

There shall also be a standing Committee on International Participation consisting of the Secretary for International Participation (who shall be Chairman of the Committee), the President, the General Secretary, and the Executive Secretary of the American Geophysical Union, and six additional persons (not necessarily AGU members) who are eminent geophysicists with knowledge and background in international organization and cooperation. The Committee shall be appointed at the first meeting of the Council following each Assembly of the IUGG, and shall serve for a term of three years to include the interval of the next Assembly. The Committee, acting on behalf of the Council shall (a) recommend to the Office of International Relations, NRC, the organization of delegations to the Assemblies of the IUGG and to such other international meetings as may be appropriate; (b) review all administrative questions that might or should be raised at, or may be related to, international meetings or assemblies with the view of fully informing our delegations of the implications thereof; (c) advise the NRC Foreign Policy Committee, or the NRC Committee on International Unions, on matters of international science policy relating to geophysical science; and (d) advise the Council of the AGU of all actions taken or initiated. The Committee shall take full account of the broad interests of geophysical science in the United States, and of the various organizations and agencies involved in geophysical activity.

To execute the affairs of the Union between meetings of the Council and in accord with its policy decisions, an Executive Committee of the Council is established to consist of the President, Vice President, General Secretary, the Secretary for International Participation of the AGU, and five members of the Council selected from among the voting members of the Council by the National Academy of Sciences upon recommendation of the Council. Only those on this committee who are members of the AGU shall exercise voice or vote in domestic or fiscal matters of the Union.

(4) *Special Committees* shall be established from time to time, as need arises, to consider special matters approved by the Council of the Union.

(5) *Appointments to Committees* of the American Geophysical Union shall be made by the President or President-Elect and appointments shall terminate at the end of the fiscal year for which they are made, unless otherwise specifically designated; no appointment shall extend, however, beyond the term of office of the appointing President or President-Elect.

(6) *Meetings of the Union* shall be called at least 30 days in advance, and those present at the meeting shall constitute a quorum.

(7) *Meetings of the Council of the Union* shall be called by the President at least 15 days in advance and a minimum of one third of the total membership of the Council shall constitute a quorum.

The Chairman of the Division of Physical Sciences, Chemistry and Chemical Technology, and Biology and Agriculture will (a) receive invitations to attend the meetings of the Council, and (b) be informed of all actions of the Union which may be of interest to their divisions. There may be a staff representative for each Division who shall be designated by name in advance to insure a continuing relationship of the Division to the Council.

(8) *Final action on matters affecting any Section* specifically shall not be taken by the Council of the Union when that Section is not represented.

(9) *Statutes and By Laws adopted by a Section or Branch* shall not conflict with the provisions of the Statutes and By Laws of the Union.

(10) *Matters pertaining solely to a Section* and not to the Union as a whole, shall be acted upon by the Section concerned.

(11) No *mail ballot* of the Union shall be closed until at least 30 days after date of issue.

(12) Officers, designated by the Council of the Union or the Executive Committee of any of its Sections, to fill *uncompleted terms,* shall not hold office without election after expiration of the period for which their predecessors were elected.

(13) *Removal from the rolls,* other than by resignation, of a Member, Corresponding Member, Associate, or Corporation Member of the American Geophysical Union shall be made only upon a three-fourths vote of a quorum of the Council of the Union; Members, Associates, and Corporation Members who fail to pay dues for two consecutive years shall be reported to the Council by the General Secretary with recommendation that their names be removed from the Union's rolls.

(14) Under special circumstances and upon request to the General Secretary any Member or Associate may be transferred to an *Inactive List* of the Union without further payment of dues and without other privileges as Member or Associate but *reinstatement* may be made upon request and payment of current year's dues.

Reelection of Members and Associates who have been dropped from the rolls by action of the Council of the Union may be effected only after filing a signed application under the usual procedure for election of Members and Associates.

(15) The Council of the Union may arrange, either through bequests, special contributions, grants, or other funds of the Union, for *awards, medals, honoraria, or certificates of merit* to geophysicists in recognition of meritorious work or service in the field of the whole Union or in the field of any of its several Sections, and for *scholarships, fellowships, or grants-in-aid* to assist worthy candidates in the advancements of geophysical science.

(16) The Council may appoint *Union or Section representatives* to other organizations, upon mutual agreement, when such representation may promote coordination and interest in geophysics. The Executive Committee of the Section concerned shall make tentative arrangements for interorganization-relationships and make selections of representatives of the Sections. Arrangements and commitments must be ratified by the Council of the Union before they are binding on the Union.

(17) The *duties of the President* shall be those ordinarily appertaining to this office; he shall preside at the meetings of the Council and at General Meetings of the Union, and shall appoint members of standing and special committees. The more important letters, and especially those concerned with policy of the Union, shall be signed by the President or the General Secretary in accordance with rules, precedents, and decisions of the Council of the Union.

(18) In the absence or in the event of the disability of the President, the Vice President shall carry out the duties ordinarily performed by the President.

(19) The General Secretary elected by the Union shall be responsible to the Council of the Union for the general administration of the Union's activities as determined by the Council of the Union. He shall serve without honorarium, and shall exercise general supervision over the Executive Secretary. He shall serve as Treasurer of the Union, receive and disburse funds in accordance with the instructions of the Council of the Union, sign checks as General Secretary on the accounts of the American Geophysical Union with depositories approved by the Council of the Union, and shall provide a surety bond in a sum set by the Council of the Union and at the expense of the Union, for funds of the Union under his control. If the General Secretary is absent or incapacitated, the President, or, if he is absent or incapacitated, the Vice President, shall sign checks against the Union accounts. The General Secretary, or the President or the Vice President serving as Treasurer in his capacity, may empower the Executive Secretary to sign checks against the accounts of the Union during their terms of office. The President, the Vice President, and the Executive Secretary shall furnish surety bonds in the same manner and amount as the General Secretary.

(20) The *Executive Secretary* shall be responsible to the General Secretary and, with the assistance of such clerical help as is necessary, shall perform all executive and other duties as indicated by the General Secretary.

(21) One copy of each issue of (a) the *Transactions*, (b) *Journal of Geophysical Research*, (c) any published *List of Members and Officers*, and (d) any other publication which may be approved for free distribution to the membership by the Council of the Union, shall be sent to each Member, Associate, and Corporation Member whose annual dues for the calendar year have been paid by February 15; any person or organization newly elected as Member, Associate, or Corporation Member shall be sent without charge one copy of these publications beginning with the calendar year in which elected and for which dues have been paid. Each member on a retired basis, Member ex officio, and Corresponding Member shall be accorded this privilege also. Each Student Member shall receive one copy of each issue of the *Transactions* and one copy of each issue of the *Journal of Geophysical Research* for each year of paid membership.

Each person and organization in good standing in any class of membership may purchase any available publication of the Union at a discount from the printed price list to non-members. The General Secretary is authorized to establish discounts for sales of publications.

Special Announcements

- **PACIFIC NORTHWEST REGIONAL MEETING**—The annual Pacific Northwest Regional Meeting will be held in Portland, Oregon, on October 31 and November 1, 1961. William E. Bullard, Public Health Service, 570 Pittock Block, Portland 5, is Program Chairman for this meeting, and Lenard M. Bissell of the Bonneville Power Administration, 10616 French Road, Vancouver, Washington is Chairman of the committee for local arrangements.
- **WESTERN NATIONAL MEETING**—The Committee for the Western National Meeting has announced that the first annual Western National Meeting of the AGU will be held December 27-29, 1961, on the campus of the University of California at Los Angeles. Each section of the AGU has been requested to organize its own program. Also, each section and the Planetary Sciences Committee have been asked to appoint a Program Chairman. The General Chairman is Prof. Joseph Kaplan, University of California (Los Angeles), Chairman of the Western National Meeting Committee, who will coordinate and integrate the various Section programs. The program will include a series of invited papers of general interest to the entire membership of the AGU, and Chairman Kaplan will welcome suggestions for such papers and speakers.

Persons interested in presenting papers at this meeting should contact any of the following officers: Joseph Kaplan, General Chairman, University of California, 405 Hilgard Avenue, Los Angeles 24, California; William W. Kellogg, Secretary of the Western National Meeting Committee, 14,739 McKendree Ave., Pacific Palisades, California; Secretaries of the appropriate Sections of AGU; Officers of the AGU.

Future meeting places for Western National Meetings have been tentatively decided as follows: 1962, Stanford University, Stanford, California; 1963, Boulder, Colorado; 1964, Pacific Northwest area.

- **IUGG SYMPOSIA SCHEDULE 1961**—The following list of symposia and conferences that have been scheduled in 1961, by the respective Associations, includes changes made since the March issue of *Transactions*. *Geodesy*—Gravity Reductions, Cambridge, England, June 1961. *Meteorology and Atmospheric Physics*—International Cloud Physics Conference, Canberra and Sidney, Australia, September 11 and 12; International Ozone Symposium, Arosa, Switzerland, August 7 to 12; International Radiation Symposium, Vienna, Austria, August 14 to 19; Changes of Climate with Special Reference to Arid Zones, Rome, Italy, October 2 to 7. *Geomagnetism and Aeronomy*—Conference on Cosmic Rays and Earth's Storms, Kyoto, Japan, September 4 to 15. *Physical Oceanography*—Basic Problems in Turbulence and Their Relation to Geophysics, Marseilles, France, September 4 to 9. *Scientific Hydrology*—Methods of Evaluating Resources of Underground Water, with Emphasis on Arid Zone Problems, Athens, Greece, October 12 to 21. *Volcanology*—Ignimbrites and Hyaloclastics, Catania, Sicily, September 15 to 24.

The Symposium on *Recent Movements of the Earth's Crust*, earlier proposed for summer 1961 at Moscow, is reportedly deferred until 1962.

- **PACIFIC SOUTHWEST REGIONAL MEETING**—The next annual Pacific Southwest Regional Meeting is tentatively scheduled to be held for 1½ or 2 days during the period January 29 to February 2, 1962, at the University of Arizona, Tucson. Persons interested in participating should communicate with the General Chairman, C. H. M. van Bavel, Southwest Water Conservation Laboratory, USDA, ARS, Route 2, Box 816-A, Tempe, Arizona. Richard K. Frevert, of the University of Arizona is Chairman for Arrangements.
- **FORTY-THIRD ANNUAL MEETING, AGU**—The Forty-Third Annual Meeting of the American Geophysical Union will be held in Washington, D. C., April 25-28, 1962; this will be in the week of the meetings of the National Academy of Sciences.
- **IUGG GENERAL ASSEMBLY, 1963**—Plans are rapidly taking shape for the 13th General Assembly of the International Union of Geodesy and Geophysics, to be held at the University of California at Berkeley, California, August 19-31, 1963. Lloyd V. Berkner, President of AGU, and Joseph Kaplan, General Chairman of the Western National Meeting Committee, will serve as Honorary Chairmen of the Committee on General Arrangements; the General Chairman of this Committee is Thomas F. Malone, who will then be President of AGU. Joseph Kaplan is Chairman of the Finance Committee. A Chairman for local arrangements will be appointed soon.
- **URSI GENERAL ASSEMBLY, 1963**—It is expected that the General Assembly of URSI will be held in Tokyo, September 15-19, 1963.

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NATIONAL ACADEMY OF SCIENCES

Number 46 • April 1961

IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation–1959 as related primarily to United States programs. The Bulletin *also reports on international programs in geophysics and space science that have grown out of the IGY, and on their results.*

Arctic Basin Seismic Studies from IGY Drifting Station Alpha

The following material is based on a report by Kenneth Hunkins, Lamont Geological Observatory, Columbia University. The original, more-detailed report, prepared by Lamont for the Geophysics Research Directorate of the Air Force Cambridge Research Laboratories, was published as AFCRC-TN-60-257, Seismic Studies of the Arctic Ocean Floor, *October 1960.*

Reflection and refraction seismic measurements made between July 1957 and November 1958 from IGY Drifting Station Alpha, built on pack ice in the Arctic Ocean, revealed details of a prominent submarine rise, referred to in this report as the Alpha Rise. This series of seismic investigations also provided information about the nature of the earth's crust beneath the ocean floor to a depth of about 3.5 kilometers.

First occupied by IGY scientific personnel in the spring of 1957, Station Alpha was abandoned in November 1958 when pressures within the ice pack destroyed the floe on which the station was constructed. During its period of occupation for IGY geophysical investigations, Station Alpha drifted along an irregular track in the North Canadian Basin, approximately within the region 83°–86° N, 115°–175° W, under the influence of ocean currents and wind. (See Figure 1.) The station's position was determined daily by astronomic fixes when cloud conditions permitted.

(Additional information on IGY Drifting Station Alpha and on its scientific programs may be found in *Bulletin Nos. 1, 4, 6, 12, 17, 22,* and *24. Bulletin No. 4* contains a preliminary report on early observations of the Alpha Rise from Drifting Station Alpha; *Bulletin No. 22* presents a preliminary report by Hunkins on the studies described in the present report [and in a report on Arctic Ocean bottom gravel, which will appear in the next issue of the *Bulletin*]; and *Bulletin No. 24* carries an analysis of ice drift in the Arctic Basin. *Bulletin Nos. 33* and *34,* which contain a two-part review of the IGY Seismology Program, explain the technique of explosion seismology and the primary uses of its two major types—reflection and refraction.)

The Station Alpha seismic studies described below were directed by Kenneth Hunkins, of Lamont Geological Observatory, under a contract from the Geophysical Research Directorate of AFCRC. Assistance in the field work was provided by Maurice Davidson, Frans van der Hoeven, Gary Latham, and Bryan Isaaks, all of Lamont, and Jack Oliver, director of Lamont's Arctic geophysics project, gave valuable advice toward analysis and interpretation of the results. Air Force personnel

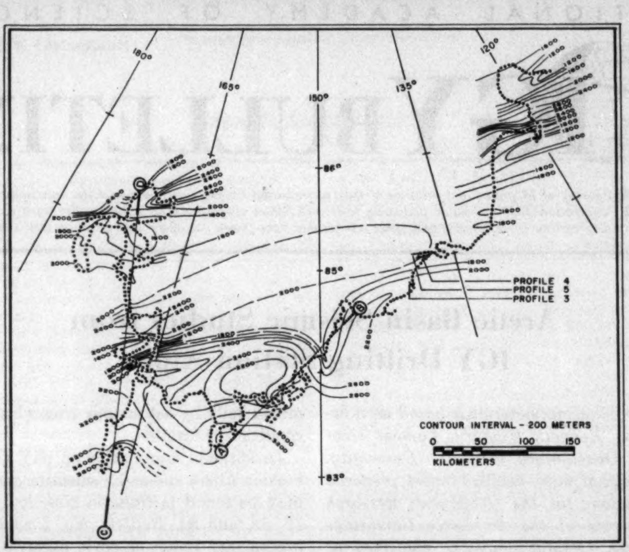

Fig. 1. *Bathymetric Chart of Arctic Basin along Track of IGY Drifting Station Alpha, June 1957–November 1958. Dots indicate station's drift path; contour interval is 200 meters. A-B and C-D are lines along which corresponding profiles in Figure 2 were drawn, and numbers 3, 4, and 5 represent locations of structure sections in Figure 3.*

contributed important cooperation and assistance.

Reflection Studies

Vertical reflection soundings were made daily in winter and twice daily in summer, and, as the floe's average drift was 5½ km per day, these soundings were usually spaced from 2 to 6 km apart along the irregular track. Unusually calm or windy periods resulted, of course, in closer or wider spacing. Sounding positions were interpolated between astronomic fixes and most are accurate to 1 km, but occasional periods of persistent cloud cover lasting several days reduced the number of fixes and, in places, lowered accuracy to 2 to 4 km. For the reflection shots, quarter-pound charges of dynamite were exploded at a depth of 3 meters below the water surface.

Bottom Reflections: The reflection soundings produced information on dip and strike of the bottom as well as on its depth. (Strike here refers to the horizontal trend of the bottom structure, and dip to the bottom slope at right angles to the strike.) A total of 623 sonic soundings were made and, of these, 555 yielded dip and strike information. The measured dips and strikes represent the attitudes of 150-meter-square areas of the ocean floor. Bottom dips ranged from 0° to 22°. The average dip was 2.70°, with a standard deviation of 2.25°, and most dips were between 0.5° and 1.5°.

The seismic depths obtained are accurate to less than one meter, and wire soundings taken at Station Alpha are in close agreement with the sonic soundings. All bottom reflections observed appear to indicate that the characteristic impedance (density × sound velocity) of the topmost sediment is greater than that of water. A sediment layer with an impedance less than that of water would probably have a thickness of less than about four meters.

Throughout its occupation, Station Alpha drifted over the submarine feature here named Alpha Rise (after the station). At the beginning of its occupation, the station was immediately south of the rise in more than 3000 meters (nearly 10,000 feet) of water. The maximum depth recorded was 3871 meters, at 82° 48′ N, 167° 01′ W. Its initial northward movement carried the station over the rise at almost right angles to its trend.

After reaching 85° 32′ N, 171° 10′ W in its northward drift, the station turned northeastward and moved nearly along the trend of the rise. Toward the end of the period of occupation of Station Alpha, the shallowest depth of 1140 meters was recorded, near the eastern end of the rise at 86° 09′ N, 114° 08′ W. The drift patterns of Station Alpha permitted detailed bathymetry for several areas of the rise, and a bathymetric chart (Fig. 1) was contoured with the aid of dips, strikes, and depth information.

The broad outline of the Alpha Rise was known previously from observations from Soviet drifting station NP-4 (1954) and from soundings of the USSR High Latitude Aerial Expeditions. The rise trends northeast-southwest across the Arctic Ocean from the edge of the continental shelf north of Wrangle Island to the shelf off Ellesmere and Axel Heiberg Islands. The Alpha Rise is sub-parallel to the Lomonosov Ridge and is twice as broad as that feature, or about 200 kilometers wide. Its crest is at shallower depths than present maps indicate: the minimum sounding over the central portion of the rise was 1426 meters, at 85° 03′ N, 171° 00′ W. To the north and south of the rise lie basins with depths greater than 3000 meters.

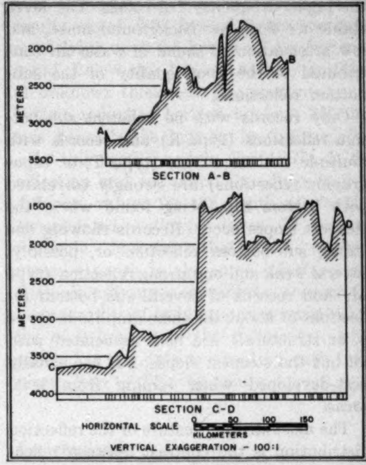

Fig. 2. *Bathymetric Profiles across the Alpha Rise. Vertical exaggeration is 100:1. Locations of profiles shown in Figure 1.*

Dip information and bathymetric profiles show that the topography of the rise is rugged (Fig. 2). The profiles strongly suggest that this is an area of fault-block mountains, although the Alpha Rise lies in an aseismic part of the Arctic Ocean and is not tectonically active at the present time.

Topographic Echoes and Sub-bottom Reflections: Several bottom echoes, or topographic echoes, are present in many of the reflection records. They occur in areas of rugged topography where several reflectors return echoes from different locations. Characteristically, the first reflection is low in amplitude and indicates a steep dip, as it comes from a topographically elevated area having relatively small reflecting surfaces. The principal bottom echo arrives shortly afterward, is of greater amplitude, and shows a flatter dip.

Sub-bottom reflections are present in the majority of the reflection records. They occur as lower-frequency events following the higher-frequency reflections. The level, stable ice floe, low background noise, and low attenuation of sound in water all contributed to the good quality of the sub-bottom reflections.

Only records with no coherent sub-bottom reflections (type R) and records with multiple bottom echoes (type T, or topographic reflections) are strongly correlated with bottom dip, being found where the steepest slopes occur. Records showing one strong sub-bottom reflection or, possibly, several weak and one strong reflection (type M) and records of several sub-bottom reflections of about the same amplitude (type S, or structural) are both associated with all but the steepest slopes, but are usually best-developed when coming from level areas.

The most striking feature of the reflection distribution is the contrast between reflections obtained on eastern and on western crossings of the Alpha Rise. For the western crossing, reflections are principally type S, with few topographic echoes. The oblique eastern crossing produced principally type M and type T records. This variation in record type cannot be due to instrumental factors or to technique, as the same instruments and shooting technique were used for all of the field work. Thus, the variation must indicate a stratigraphic or structural difference between the eastern and western ends of the Alpha Rise.

The type T records show that bottom texture is rougher in the eastern area. The M reflection in the eastern area probably corresponds to a "second reflection," observed several years earlier by A. P. Crary and N. Goldstein from ice-island T-3 in the area 84°–88° N, 70°–100° W. They found this "second reflection" 210–340 meters below the bottom. It is likely that the kind of bottom topography producing the type M reflections recorded from the eastern Alpha Rise by Station Alpha investigators continues eastward to the area covered by T-3.

The strong type M echo indicates a good impedance contrast, probably representing the interface between the unconsolidated sediments and the underlying rock. In the western area, where a single strong reflection is absent, the impedance contrast at the base of the sediment may be low due to an underlying rock having properties little different from the overlying sediment. The reflections of the type S record would, if this were the case, result from layering within the unconsolidated sediment.

Refraction Studies

During the spring and summer of 1958, five unreversed refraction stations were made at Drifting Station A. Of these stations, the last three (see Fig. 1) recorded the refracted ground wave as a "first arrival." The charges used ranged from 25 to 75 pounds of TNT fired about 2 to 3 meters below the water surface, and the right-angle array of geophones permitted measurement of the apparent velocities and azimuths of the arrivals. Figure 3 summarizes graphically results of the three refraction profiles discussed below.

Refraction Profile No. 3: On July 25, 1958, a refraction station was made in the vicinity of 84° 45′ N, 140°W. The ocean bottom beneath the receiver was at a depth of 2085 meters and had a dip of 6°. The interpreted structure section shows the water column to be underlain by 0.48 km of sediment with a seismic-wave velocity of 2 km/sec; below this lies an undetermined thickness of material with a velocity of 5.52 km/sec.

On several reflection records taken in the vicinity, a type M sub-bottom reflection appears and, in the vicinity of the profile, the depth to this horizon is about 200 meters.

Refraction Profile No. 4: A profile of three shots was made on August 2, 1958, in the vicinity of 85° N, 138°–139° W. The vertical-reflection record at the receiver showed 1813 meters of water and a bottom dip of 2°. A sub-bottom reflection at 342 meters was also shown, and the indicated

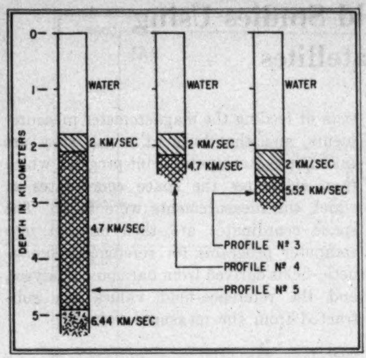

Fig. 3. *Structure Sections for Refraction Profiles, on the Alpha Rise. Seismic-wave velocities of bottom materials and underlying bedrock are shown. Profile locations indicated in Figure 1.*

reflection horizon dipped more steeply than the bottom. Low-angle reflections indicated high topography between the closest shot point and the receiver. The interpreted structure indicates that directly beneath the water column is a layer of 2 km/sec material 0.37 km thick, underlain by an undetermined thickness of 4.7 km/sec material.

The prominent reflection horizon at 342 meters at the receiver site, and 350 meters near the shot point, agrees closely with the 370-meter thickness of the 2 km/sec layer found by refraction. Apparently this prominent reflector is the base of the upper low-velocity sediment in this area.

Refraction Profile No. 5: A profile was made on August 3, 1958, very close to the area of Profile No. 4. Interpretation of the results shows 0.29 km of 2 km/sec sediment lying upon 2.8 km of 4.7 km/sec material. Below this lies a 6.44 km/sec layer of unknown thickness. The prominent subbottom reflection horizon is about 350 meters beneath the bottom in this vicinity.

In this profile, and in Profile No. 3, the reflection and refraction soundings lead to different values for the depth of the unconsolidated sediment layer. It appears probable, however, that both methods measure depth to the same interface, but that simplifying assumptions (concerning horizontality of bedding and a wave velocity of 2 km/sec in the sediments), when applied to the data received by each technique, lead to differing results.

Conclusions

The Alpha Rise is one of the large positive features of Arctic Ocean topography. Relief on the rise is rugged and is apparently the result of block faulting. Although only three short refraction profiles supplied crustal data, they tend to show results similar to those reported for the North Atlantic Ocean by J. Ewing and M. Ewing, 1959.

The average thickness of the upper, or unconsolidated, layer of bottom material was 0.38 km, as compared to ½ to 1 km in the North Atlantic. A single measurement indicating a thickness of 2.8 km was made for a deeper, 4.7 km/sec layer. The seismic-wave velocity of the deeper, "oceanic" layer was 6.44 km/sec, which is in close agreement with the velocity of about 6.5 km/sec found in the North Atlantic.

Geomagnetic-Field Studies Using Earth Satellites

The following report is based on a paper by J. P. Heppner, J. C. Cain, I. R. Shapiro, and J. D. Stolarik, presented at the Twelfth General Assembly of the International Union of Geodesy and Geophysics (IUGG), held in Helsinki, Finland, July 1960. The authors of the paper are associated with the Goddard Space Flight Center of the National Aeronautics and Space Administration.

The Vanguard III satellite (1959 Eta), launched on September 18, 1959, by the Goddard Space Flight Center, carried a specially designed proton-precessional magnetometer to help chart the earth's magnetic field in space. (See *Bulletin No. 28.*) The lifetime of the experiment was approximately three months (September 18—December 12, 1959), during which numerous magnetic-field measurements were made throughout an altitude range of about 510–3750 kilometers (about 320–2330 statute miles) and between geographic latitudes of 33.5° N and S and geomagnetic latitudes of 45° N and S.

During Vanguard III's 85 days of operation, approximately 4300 successful responses to ground commands (about 50 per day) were recorded by the Minitrack stations. Each command yielded one proton-precessional signal of approximately two-seconds duration, and, from tapes thus far played back, it appears that 80% of the signals will yield measurements of high accuracy.

Analyses of the data collected by Vanguard III are contributing to evaluations of the accuracy of magnetic charts and computed geomagnetic fields, determinations of possible discontinuities in the earth's magnetic field, and further knowledge of geomagnetic storms and their effects. The data-reduction procedure consists of feeding the magnetometer measurements, and the times at which they are taken, into a computer orbit program which then calculates the space coordinates at which the measurements were taken. The space coordinates are then entered into computer programs for reference geomagnetic-fields derived from harmonic analyses, and the reference-field values are subtracted from the measured values.

Accuracy of Magnetic Charts and Computed Geomagnetic Fields

A by-product of using computed fields for reference is that information is gained that relates directly to some long-standing questions in geomagnetism pertaining to analysis of the earth's main magnetic field. The first of these concerns the accuracy with which fields in space can be computed from analyses of surface charts. A general answer based on a preliminary review of the Vanguard III measurements is that the average error is about 1%. This is in general agreement with opinions expressed prior to the experiment by E. H. Vestine and others. The 1% figure also indicates that the charts used in deriving coefficients are in error by at least 1% in low latitudes. As noted by D. C. Jensen and W. A. Whitaker, the errors in some regions are probably much greater.

A second question of long standing in geomagnetism is whether significant field effects occur at altitudes of several thousand miles, within geographical dimensions comparable to those represented by the higher-order terms of computed fields. The answer is definitely "yes," in some regions, unless external field sources at similar altitudes are postulated. The satellite data obtained over southern Australia clearly illustrate this. In these data, curves for the

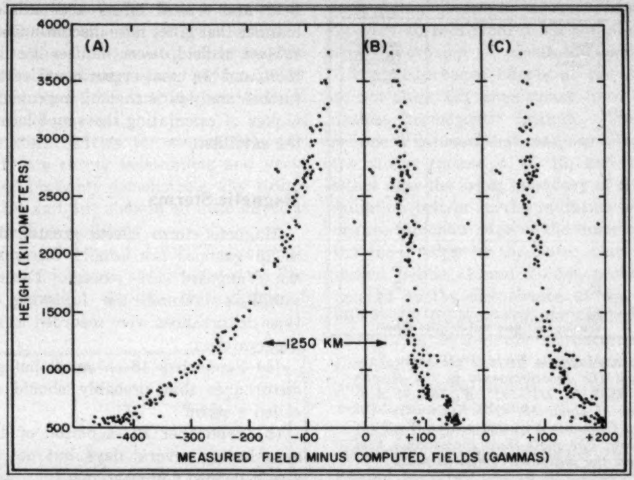

Fig. 4. *Magnetic Field Plots from Vanguard III Measurements in the Region 32°–33.5° N, 111°–121° W, and at Altitudes of about 510–3750 Kilometers—Orbital Elements Adjusted at One-Month Intervals. The plots show the field measured by the satellite minus computed fields as follows: A, using coefficients of H. F. Finch and B. R. Leaton; B, using coefficients of D. C. Jensen and W. A. Whitaker, based on US Navy Hydrographic Office charts; and C, using Jensen and Whitaker coefficients based on Russian magnetic charts.*

same latitude range are clearly shifted relative to each other over several degrees of longitude at altitudes up to 2000 miles.

Field Discontinuities

Magnetic-field discontinuities of a permanent or semi-permanent nature are not expected to be found between altitudes of 510 and 3750 km, since diamagnetic effects in the inner radiation belt are expected to be too small and most drift theories place currents at greater altitudes. However, following a computer run in May 1960, the attention of the investigators was directed to the possibility of a field discontinuity at the lower edge of the inner Van Allen belt. Nearly all of the plots of the type in Figures 4 and 5 showed obvious discontinuities or slope changes in the region 1250–1600 kilometers.

Additional interest was generated when it was found that the largest field changes during magnetic storms occurred in the boundary regions of the inner belt (discussed below). A confusing factor was that the majority of the discontinuities occurred either at adjustments of orbital elements in the computer program or when data on opposite sides of such adjustments were not continuous with time. However, several exceptions were found in which the data were continuous with time, and these exceptions, together with the similarity of behavior of a large number of curves, led the investigators to believe, with considerable reservation, that a field discontinuity was present at the lower edge of the inner Van Allen radiation belt.

As a further test, new orbital arcs were evaluated, in July 1960, over monthly (Fig. 4) rather than weekly (Fig. 5) intervals,

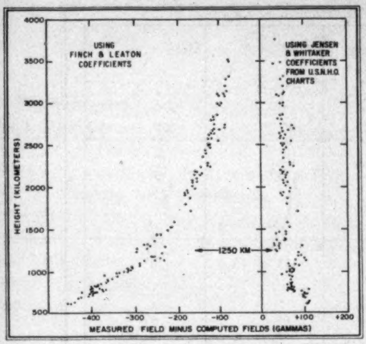

Fig. 5. *Magnetic Field Plots from Vanguard III Measurements in the Region 32°–33.5° N, 111°–121° W, and at Altitudes of about 510–3750 Kilometers—Orbital Elements Adjusted at One-Week Intervals. The plots show the satellite field minus the indicated computed fields.*

thus reducing the number of discrete orbital transitions from eleven to two. The principal effect of the new computation in comparison with the old was that a number of the sharp discontinuities in the 1250–1600 km range disappeared. Figures 4 and 5 provide a striking example of this difference at an altitude of 1250 km.

The disappearance of discontinuities when one-month orbital arcs are used makes the existence of a permanent discontinuity at the lower edge of the inner belt appear very doubtful. In spite of this, the possibility cannot be dismissed. Most curves of field difference with altitude still show a maximum rate-of-change of slope in the 1250–1600 km range, and, in some regions, the change from weekly to monthly orbital arcs did not greatly alter the appearance of the curve. Thus, for the portion of Vanguard III's orbit passing over southern South America, near the region where the magnetic field at the earth's surface is at a minimum, it must be assumed that either there are field discontinuities or that the various effects due to reference-field and orbital errors accumulate in a manner that gives false discontinuities. The subject of field discontinuities is still open, then, and the most urgent consideration for further analysis is that of improving techniques of calculating the space location of the satellite.

Magnetic Storms

Magnetic-storm effects greater than 10 to 15 gammas are usually discernable in the Vanguard III records. During the satellite's lifetime, the following storm-type disturbances were recorded at surface observatories:

(a) September 18—a small but general disturbance that probably should not be called a storm.

(b) September 20—a period of disturbance lasting several days but not having a well-defined commencement.

(c) October 3—a period of disturbance having a gradual onset but with the horizontal component of the earth's magnetic field depressed uniformly with latitude over a number of hours.

(d) October 30—sharp SC (sudden commencement of a magnetic storm) at 23:48 GMT on October 29, followed by several days of weak-to-moderate disturbance.

(e) November 28—sharp SC at 23:51 GMT on November 27 (shown in Figure 7).

(f) December 5—sharp SC at 07:00 GMT on December 5, followed by large disturbance of classical appearance in the horizontal component.

In (a), (b), and (d), most of the readings do not deviate from the values for magnetic quiet periods. A close examination, however, does indicate that disturbances up to 20 gammas may often be present. The sign of these small deviations is more often negative than positive when the horizontal component on the ground is negative, but the correlation is poor. The most notable exceptions to the generally small magnitudes occur for storm (d) in measurements obtained on two satellite passes near latitude 20° S in which deviations of —40 to —70 gammas occurred. On the other hand, several other satellite passes in the same region during similar disturbed conditions recorded deviations of less than 20 gammas.

The storm effects for storms (c), (e), and (f) are rather outstanding and peculiar, and probably demonstrate why storms (a), (b), and (d) showed so little effect at the satellite's position.

Storm of October 3, 1959: The principal effects of this storm are illustrated in Figure 6. Points 1 through 15 in Figure 6 represent, chronologically, all readings taken from the time the storm showed an appreciable disturbance in the horizontal component on the ground to a time just before most ground observatories recorded a sharp recovery to zero from a horizontal-component disturbance of about 100 gammas.

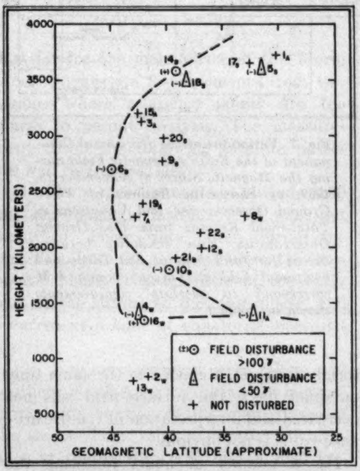

Fig. 6. *Geomagnetic-Field Disturbance during Storm of October 3, 1959. Satellite measurements received at various tracking stations are plotted (in terms of relative intensity of disturbance) against altitude and geomagnetic latitude. S indicates San Diego station; B, Blossom Point; A, Antigua; and W, Woomera.*

The disturbance effects at the satellite do not show any consistency until plotted against geomagnetic latitude. When this is done it is found that readings affected by the storm (points 4, 6, 10, and 11), lie either near the lower boundary of the inner radiation belt or in the radiation slot that defines the outer edge of the inner belt and the inner edge of the outer belt. Undisturbed points (1 and 2) can probably be ignored as the disturbance at the ground was small. However, points within the belt (3, 5, 7, 8, 9, and 12) all occurred when the negative horizontal-component disturbance was large (about 100 gammas) at nearby ground stations.

Following point 12 in time, the horizontal component returned suddenly to zero at ground observatories in low latitudes over most of the earth; following this unusual happening, in turn, the horizontal component again became negative and was irregular for another day. Points 13 through 22 represent, in time sequence, the measurements taken at geomagnetic latitudes greater than 25° during this period. Points 14 and 16 were disturbed by +170 and +120 gammas, respectively, during times when the horizontal component was negative at nearby ground stations. Points 15, 19, 21, and 22, which were not disturbed, occurred during times when the horizontal component was similarly depressed, and points 13, 17, 18, and 20 occurred when the disturbance was very small.

Readings at low latitudes were confined to the beginning of the disturbance (prior to point 1) and to a period between points 12 and 13 when the disturbance was small. These times also correspond to local times of equatorial electrojet activity in South America. The readings were either undisturbed or disturbed by —10 to —20 gammas, with the exception of a measurement of +40 gammas near the start of the disturbance.

Storm of November 28, 1959: The behavior of this storm is illustrated in Figure 7 in the conventional manner of showing the horizontal component from several observatories. Total-field records from two stations are also shown to illustrate, first, the similarity of appearance of the total field at San Diego and the horizontal component at Tucson, and second, the behavior of the total field when a large vertical-component variation is present at a station at a magnetic latitude greater than 40°.

Used in conjunction with Table 1, Figure 7 constitutes a reference of disturbance against time for the satellite measurements. With the exceptions of I, K, L, and M, the readings were taken in the same general regions as the records shown in Figure 7.

Six points in Figure 7 (A, B, C, G, I, and L) could be superimposed on Figure 6, where they fall within the radiation-belt side of the dashed line. These points are not disturbed, with the exception of point (C), which falls close to the line. Of the three points at low altitudes (F, H, and J) only one, point F, is disturbed.

Of the two points (D and E) falling close to but outside the boundary, point D is not disturbed. However, it should be noted that the two measurements for point D were only 5 seconds apart in time and differed by 20 gammas relative to the reference fields. This may indicate the presence of rapid changes. Point E is so exceptional that it was at first not accepted. However, independent rechecks confirmed the three readings with high accuracy and the investigators have been unable to find a reason to doubt its validity. The fact that point F, taken 11 minutes later at a lower altitude and greater latitude showed —40 gammas in comparison with about +460 for point E, may indicate that the disturbance for point E was highly localized along a boundary, but this can only be a postulate for the present.

Point K was taken over the magnetic equator during the morning increase in field intensity caused daily by the equatorial electrojet. Relative to the same time on quiet days, the surface field was not decreased and interpretation of the disturbance value is not obvious.

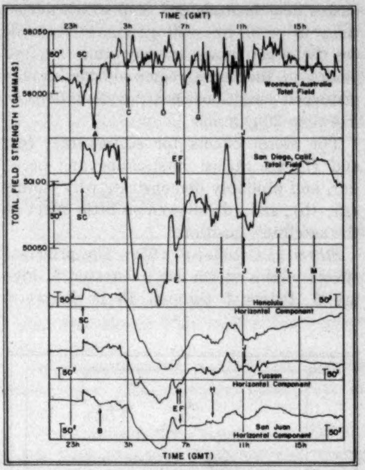

Fig. 7. *Variations of the Horizontal Component of the Earth's Magnetic Field during the Magnetic Storm of November 28, 1959, as Shown in Records of Three Ground Observatories, and Variations in Total-Field Records from Two Ground Observatories. Note similarity between curves for total field at San Diego and horizontal field at Tucson; points A-M correspond to satellite measurements shown in Table 1.*

For a number of hours following the time limits of Figure 7, the horizontal component shown in ground records remained depressed. A number of satellite measurements obtained from North America and Australia showed no disturbance, except for two passes that would fall near the dashed line of Figure 6. These showed disturbances of +20 and —20 gammas at altitudes of 3650 and 1200 kilometers, respectively.

Storm of December 5, 1959: Only a small number of measurements have been reduced

Table 1. Vanguard III Observations during Magnetic Storm on November 28, 1959
(Reference Table for Figure 7.)

Point	Time (GMT)	No. of Measurements	Average Geographic Coordinates Long. (deg)	Average Geographic Coordinates Lat. (deg)	Height (Km)	Approx. Geomagnetic Latitude (degrees)	Satellite Total-Field Disturbance (gammas)
A	00:44	3	137 E	19.5 S	2080	30 S	0
B	02:05	2	62 W	20.2 N	1560	31 N	0
C	03:07	3	136 E	31.5 S	3040	42 S	−40 to −60
D	05:33	2	128 E	32.3 S	3667	43 S	0
E	06:28	3	117 W	25.5 N	1290	33 N	+450 to +470
F	06:39	3	77 W	33.5 N	680	45 N	−40
G	08:01	2	137 E	21.6 S	3635	32 S	0
H	09:00	1	61 W	23.1 N	550	34 N	0
I	09:33	4	28 E	29.2 S	2740	30 S	0
J	11:05	2	117 W	30.8 N	530	38 N	0
K	13:37	4	76 W	9.5 S	1465	2 N	−20 to −40
L	14:24	3	28 E	26.4 S	3740	27 S	0
M	16:04	1	70 W	29.4 S	2723	18 S	0

thus far for the main phase of this storm and these include measurements from two regions where reference points are too sparse to permit analysis. The measurements from the following satellite passes are well referenced, however:

(1) Three measurements at altitude 1200 km and magnetic latitude 7° S were not disturbed. These were taken during the transition from the positive-horizontal-component phase (characteristic of the early part of the storm) to the main phase, and occurred at a time of equatorial-electrojet activity.

(2) Two measurements were taken over southern South America during the increasing-activity portion of the main phase of the storm. They show a negative disturbance at the satellite altitude of 2050 km.

(3) Four measurements at an altitude of 1000 km and magnetic latitude of 43° were not disturbed. These were taken during the decay of the main phase when the negative horizontal-component disturbance was about 40 gammas on the earth's surface.

Discussion of Storm Effects

Between magnetic latitudes of 25° and 45°, the magnetic-field observations of Vanguard III bear little if any resemblance to those of phenomena predicted in various magnetic-storm theories. It also appears doubtful that the various mechanisms proposed for creating magnetic storms can be used to explain these satellite observations, since, to fit them, a mechanism must be found for creating boundary currents, or their equivalent, on the inner Van Allen radiation belt (including the lower edge of the inner belt).

The most fundamental question is whether such boundary currents are a cause of magnetic disturbance or a result of a boundary reaction to an external phenomenon. Particle measurements made with satellites during magnetic storms have demonstrated that the "slot" between the radiation belts (or the inner part of the outer belt) shows marked changes during magnetic storms. The principal effects are: (i) during the main phase of a storm, radiation from the outer radiation belt is dumped into regions of lower latitude and altitude, and (ii) late in the recovery phase of a storm, the electron content of the outer zone increases. Radiation in the inner belt apparently remains unchanged during geomagnetic storms.

Two factors must be known before an adequate tie can be made between particle behavior and magnetic phenomena; they are: (i) the mechanism for accelerating or scattering particles out of the outer belt, and (ii) the energy and density of electrons in the inner belt. Without these, explanations must remain speculative.

The preferred explanation of the investigators, on the basis of available data, is that the boundary phenomenon is caused by activity external to the inner belt. Explanations for the boundary disturbances and for the lack of disturbance within the inner belt at magnetic latitudes greater than 25° can be sought by treating the inner belt as though it had super-conducting properties leading to induction currents on its outer surface, and by finding a mechanism that would give a sufficient particle gradient near the boundary to generate Hall currents.

Within the framework of the available data, however, it cannot be assumed that lack of change within the inner belt is conclusive evidence that it is a "dead" region during magnetic storms. At this point it cannot be explained why magnetic disturbances between 510 km and the lower edge of the inner belt at magnetic latitudes less than 25°, and at various altitudes in low magnetic latitudes, do not in general correlate with what is observed on the earth's surface. The role of ionospheric currents undoubtedly enters into this question but it would be surprising to find that they provide all the missing links.

One conclusion that can be drawn is that a transition in magnetic-storm phenomena can be expected in magnetic latitudes corresponding to the slot between the two radiation belts—roughly, magnetic latitudes 41°–46°. Additional evidence for this may be found in the behavior of the vertical component of the geomagnetic field at surface observatories during magnetic storms. Studies such as one carried out by S. Matsushita in these latitudes have shown that variations of the vertical component are consistently different at closely spaced stations. This is attributed to local induction effects caused by variations in ground conductivity. The question arises, however, of why these induction effects are so prominent. The answer may be that rapidly varying localized currents are generated in the slot region between the inner and outer belts during magnetic storms.

The Explorer IX Atmospheric-Density Satellite

The Explorer IX satellite, a gas-inflated, 12-foot, plastic and aluminum-foil sphere designed for use in atmospheric-density studies based on the effects of air drag on the satellite's orbit, was launched by the National Aeronautics and Space Administration from its Wallops Island, Virginia, station at 8:05 am EST, February 16, 1961. The satellite, also designated 1961 Delta in accordance with the astronomical identification system devised for satellites and space probes by the Smithsonian Astrophysical Observatory, was injected into orbit about 10½ minutes later and about 1280 miles downrange. (See Figure 8.)

After the satellite's beacon radio signal had been received initially by the NASA Minitrack station at Woomera, Australia, about an hour and 15 minutes after launch, the radio ceased functioning and the satellite was "lost" until sighted visually a few hours later by a South African Moonwatch

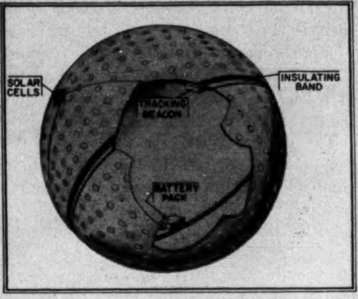

Fig. 8. *Explorer IX Inflatable Sphere Satellite. Cut-away section reveals locations of tracking beacon and battery pack; white dots help regulate temperature. From NASA photograph.*

team. Further visual and photographic sightings have shown Explorer IX to be approximately in its planned orbit, and, using optical observations to supply the necessary orbital data, the atmospheric-density experiment is proceeding.

Explorer IX was carried into orbit by a four-stage, all-solid-propellant Scout research rocket in the first successful launch using a vehicle fueled entirely by solid propellants. An important additional purpose of the Explorer IX launch was to flight-test the Scout rocket in order to gain further knowledge of its performance, structural integrity, and internal environmental conditions, and of the reliability of its guidance-control system. The Explorer IX launch was also the first successful United States satellite launch from NASA's Wallops Island Station—the first, in fact, from any United States site other than Cape Canaveral, Florida, on the Atlantic Missile Range, or Vandenburg Air Force Base, California, on the Pacific Missile Range.

Immediately after it was ascertained that Explorer IX was in orbit, a telegram giving orbital and experimental information was sent by the Space Science Board (SSB) of the US National Academy of Sciences to the Committee on Space Research (COSPAR), in the Hague, for transmittal to all COSPAR participants. Data obtained in the course of the atmospheric-density experiment will be forwarded to COSPAR and will also be deposited in the IGY World Data Centers.

Orbital Data

Explorer IX was launched eastward from Wallops Island on an elliptical flight path with initial perigee about 394 and apogee about 1607 statute miles above the earth. The belt covered by the initial orbits extends 38.9° north and south of the equator and the satellite's initial orbital period was calculated to be 118.55 minutes. Explorer IX was programmed for a velocity of approximately 17,866 mph at injection into orbit and at perigee. Its initial speed at apogee was about 14,000 mph.

Atmospheric-Density Experiment

The primary purpose of the Explorer IX inflatable-sphere experiment is to improve our knowledge of the density of the earth's atmosphere in the altitude range covered by the satellite's orbit, and of the variations in density with time and location, and under solar influence. Several different methods have been used through the years to measure atmospheric density. One method is to carry instruments aloft by balloons, which reach altitudes of about 20 miles. Another employs sounding-rocket techniques to measure air density to altitudes above 100 miles. (See *Bulletin Nos. 13, 14, 32.* and *40.*)

In recent years, particularly during the IGY, satellites such as the Sputniks, Vanguards, Explorers, and Echo I have extended knowledge of atmospheric density to nearly 1000 miles and have revealed that the density of the upper atmosphere is influenced markedly by solar storms. (See *Bulletin Nos. 32* and *44.*)

At present, atmospheric density at satellite altitudes is inferred from calculations of tracking data obtained from the numerous satellites of different sizes and shapes, such as those named above. Because of the spherical shape of the Explorer IX satellite, however, the drag force acting on it depends only on atmospheric density and not on the satellite's attitude, as with nonspherical satellites. Thus, more accurate density values can now be obtained.

In the Explorer IX experiment, the orbiting spherical satellite is actually the measuring instrument. As the satellite, an object with a known mass and frontal area and highly sensitive to drag, slowly descends and dips more and more into the earth's atmosphere, it continually loses energy as a result of the minute force (estimated to be less than one-thousandth of an ounce for this satellite) exerted on it by the earth's atmosphere. Because of the relatively light weight of the 12-foot balloon, this small drag force results in measurable changes in its orbit. World-wide optical-tracking measurements of these orbital changes supply the information needed to determine the drag force accurately, and from this information, in turn, the atmospheric density can be computed for numerous points along the orbital path.

Description of Satellite

The Explorer IX plastic-sphere satellite was conceived, built, and packaged at NASA's Langley Research Center, and the laminated material used to construct the inflatable sphere was fabricated to NASA specifications by the Reynolds Metals Company.

Total payload weight is 75 pounds, of which the 12-foot inflatable satellite weighs 15 pounds. The fourth-stage rocket and the attached payload container weigh about 127 pounds.

Approximately twice the thickness of the cellophane on a cigarette package, the satellite skin is constructed of four alternate layers of mylar plastic film and aluminum foil, the final layer of foil making up the exterior surface. Each layer is 0.0005 of an inch thick, resulting in a total thickness of approximately 0.002 inch, or two mils. The sphere was fabricated by bonding together 40 flat gores of this aluminum-mylar laminate.

The plastic layers give the satellite the toughness it requires to be folded into a compact package for ease of transport into orbit. The aluminum gives the inflated satellite rigidity and makes it highly reflective of sunlight and radio waves, and electrically conductive; it also helps regulate satellite temperature and protects the plastic film from the intense ultraviolet radiation in this area beyond the protective filtering effects of the earth's atmosphere.

The rigidity provided by the aluminum foil keeps the satellite spherical, without internal pressure, as it circles the earth. After separation of the satellite and payload container, gas pressure in the sphere is equalized with the outside pressure by means of a valve. Any remaining inflation gas is expected to be lost through puncture of the satellite skin by micrometeorites.

Studies conducted at Langley indicate that the aluminum foil reflects about 85% of the sunlight falling upon it, permitting the sphere to be tracked optically throughout the world. To obtain better heat balance for the tracking beacon components, over 20% of the satellite surface area was covered with a pattern of two-inch-diameter white dots.

The deflated satellite was folded accordion-fashion inside a metal tube, 8½ inches in diameter and about 19 inches long, mounted on the front end of the fourth-stage rocket. Together, the satellite and its attached tracking-beacon components filled about the first 11 inches of the tube. In the space behind the folded satellite was an ejection bellows, a steel inflation bottle containing nitrogen gas under a pressure of about 1800 pounds per square inch, and the fourth-stage telemeter and its batteries. (See Figure 9.)

Radio Equipment: For tracking pur-

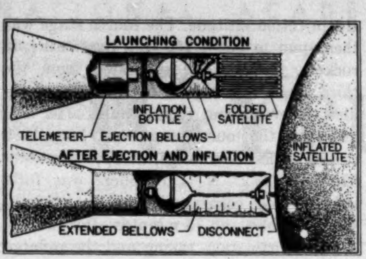

Fig. 9. *Explorer IX Payload Before and After Ejection and Inflation. From NASA photograph.*

poses, a 2¼-pound, 3 × 4-inch radio beacon powered by miniature storage batteries and 280 solar cells was attached to the sphere's inside surface near the equatorial gap (see Fig. 8). The storage batteries were to supply the necessary power while the satellite is in darkness.

The fourth-stage rocket casing of the Scout launch vehicle, in approximately the same orbit as the satellite, also contains a small tracking beacon. When the sphere's beacon ceased operating, it was possible to establish the approximate orbit of both satellite and rocket casing from signals received from the rocket-casing beacon by NASA Minitrack stations, thus making it easier to locate the sphere by visual and optical means.

Tracking

With failure of the radio-tracking beacon carried by Explorer IX, it became necessary to rely entirely on the network of high-precision Baker-Nunn tracking cameras, established during the IGY (see *Bulletin No. 12*), to supply the accurate orbital data needed for the atmospheric-density experiment. Optical tracking of the highly-reflective satellite is under the direction of the Smithsonian Astrophysical Observatory, and the fourth-stage rocket casing is also being tracked optically by the SAO network.

Scout Launch Vehicle

The launch was also part of NASA's Scout development program to provide the United States with a small, relatively inexpensive, reliable and flexible solid-fuel booster for space probes and satellites. The Scout research rocket has been under development by the NASA Langley Research Center since mid-1958. A number of Federal and private agencies participated in development and construction of the vehicle and its launch facilities.

The Scout vehicle is designed to place a 150-pound satellite into a circular orbit approximately 300 miles above the earth or to loft a 50-pound scientific probe vertically to an altitude of about 8400 miles. In reentry body tests, Scout will permit simulation of conditions expected by a space vehicle returning to the earth's atmosphere. With a ballistic trajectory, it will be possible to obtain almost two hours of zero-gravity environment with 100-pound experiments.

Description of Vehicle: The Scout first stage, named Algol for a fixed star in the constellation Perseus, is 30 feet long, 40 inches in diameter, and develops 103,000 pounds of thrust. The first stage is fin-stabilized and controlled in flight by jet vanes. It is the largest solid-fuel rocket flown thus far in the United States. The second stage, Castor, is 20 feet long, 30 inches in diameter, and has a thrust of more than 62,000 pounds. A modification of the Sergeant rocket, the Castor rocket used in the Scout vehicle is stabilized and controlled by hydrogen-peroxide jets. Castor is a star in the constellation Gemini.

The Scout third stage is named Antares for the brightest star in the constellation Scorpio. The rocket is 10 feet long and 30 inches in diameter, with a thrust in excess of 13,600 pounds. Stabilized and controlled by hydrogen-peroxide jets, and utilizing lightweight plastic construction throughout its design, Antares is a "scaled-up" version of Altair, the fourth stage. Altair, six feet long, 18 inches in diameter, and having 2800 pounds of thrust, is named for a star of the first magnitude in the constellation Aquilae, or Eagle. The spin-stabilized Altair, the smallest of the four Scout stages, formerly known as X-248, has been used as the third stage on the Able and Delta launch vehicles and was the first fully developed rocket to utilize lightweight plastic construction throughout.

Launch Sequence: After launch, the Scout's first stage remained attached to the vehicle until second-stage ignition, 70 seconds later and at an altitude of 130,000 feet. The second stage carried the vehicle to about 310,000 feet and was blast-separated 116 seconds after launch when the guidance programmer ignited the third-stage rocket motor. After burnout, the spent third stage, with its guidance and control system operating, coasted for over seven minutes to the injection altitude. The fourth stage was then spun to about 150 rpm by small spin rockets, ignited, and separated from the third stage. Injection into orbit was scheduled to occur about 10½ minutes after liftoff, when the fourth stage was about 1280 statute miles downrange, at approximately 52.5° W, 35.2° N. The sphere was fully inflated and separated from the fourth-stage rocket about 15 minutes after launch.

The fourth-stage casing and the inflated sphere are expected to become increasingly separated in orbit because of differences in drag. Since the sphere is hundreds of times more sensitive to atmospheric drag, it is expected to remain in orbit from a few weeks to, possibly, a year before spiraling into the lower atmosphere and burning up. The predicted lifetime in orbit of the spent fourth-stage rocket motor is considerably longer.

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A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation–1959 as related primarily to United States programs. The Bulletin *also reports on international programs in geophysics and space science that have grown out of the IGY, and on their results.*

Analysis of Gravels from the Arctic Ocean Floor

The following material is based on a report by Walter Schwarzacher, of Queens University, Belfast, Northern Ireland, and Kenneth Hunkins, of the Lamont Geological Observatory, Columbia University. The original, more-detailed report, prepared by Lamont for the Geophysics Research Directorate of the Air Force Cambridge Research Laboratories, was published as AFCRC-TN-60-258, Dredged Gravels from the Central Arctic Ocean, *October 1960. An associated report on seismic studies of the Arctic Basin appeared in* Bulletin No. 46, *April 1961.*

Among the investigations conducted at IGY Drifting Station Alpha during its period of occupation, was a program of collecting dredge and core samples from the floor of the Arctic Ocean along portions of the drift-path of the ice floe on which the station was built. The dredge samples taken consisted mostly of glacial gravels, predominantly of sedimentary composition, which are believed to have been ice-rafted from shore areas to the central portions of the Arctic Basin.

A series of nine bottom-trawl operations obtained the dredge samples when the station was in the region 84°–85°N, 138°–152°W. (See Figure 1.) Also obtained in these studies were 14 bottom cores and about 200 bottom photographs. The high percentage of gravels and sands on the Arctic Ocean floor is the most remarkable sedimentation feature observed in this region. The relative density of such gravels is impressively seen in the bottom photographs. (*Bulletin No. 46* provides background information on Drifting Station Alpha and its program of IGY geophysical studies, and refers to earlier *Bulletins* also containing reports on the station, its programs, and related Arctic Basin studies.)

Sampling and Analysis Techniques

Most of the gravel samples were taken with a small bottom trawl consisting of a net held in place by a steel frame. The mouth opening was 10 × 100 cm, and the net had a mesh of 0.5 mm. The trawl was towed by the drifting ice floe for periods of one to four hours, and the actual distance traveled by the trawl on the bottom ranged from about 300 to 1600 meters. One sample was also obtained with a bucket dredge and another with a grab sampler. In addition, one rock was brought up accidentally when it became wedged in a sprocket wheel

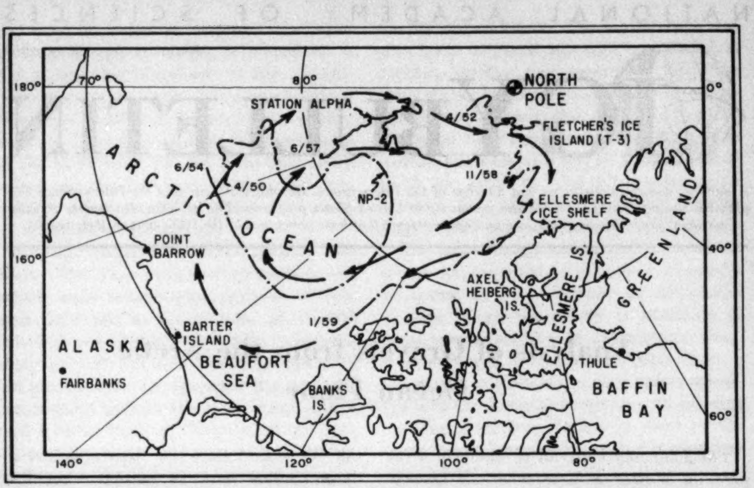
180°
70°
80°
NORTH POLE
0°
STATION ALPHA
4/52
FLETCHER'S ICE ISLAND (T-3)
ARCTIC OCEAN
6/57
6/54
4/50
NP-2
11/58
ELLESMERE ICE SHELF
GREENLAND
POINT BARROW
160°
40°
AXEL HEIBERG IS.
ELLESMERE IS.
BARTER ISLAND
1/59
ALASKA
FAIRBANKS
BEAUFORT SEA
BANKS IS.
THULE
BAFFIN BAY
60°
140°
120°
100°
80°

Fig. 1. *Drift Paths of US-IGY Station Alpha, Fletcher's Ice Island, and USSR Station NP-2 in the North Canadian Basin. Arrows indicate circulation pattern in this portion of the Arctic Ocean. Solid line shows path of Station Alpha, broken lines those of Fletcher's Ice Island and NP-2.*

used as a weight during another study. Obviously, material collected by these methods represents only the topmost layers of the bottom sediment.

The samples consisted generally of one to four liters of brown mud mixed with various amounts of sand and gravel. Since the mesh of the dredge net was 0.5 mm, the samples represent the bottom sediment only for particle sizes greater than this. The smaller fractions, best examined in the core samples, are partly normal marine sediment and partly glacial marine sediment.

All dredge samples were washed and sieved, and the fraction consisting of grain sizes larger than 3 mm was examined in detail under the binocular microscope. Sandstone, shale, and metamorphic and igneous rock types were separated by inspection; limestones [$CaCO_3$] and dolomites [$MgCa(CO_3)_2$], were differentiated by chemical staining. Gravels larger than 20 mm in size were thin-sectioned and examined under the polarizing microscope.

The composition of the various sieve fractions seems to vary with some regularity. Especially notable are the increase of shale and sandstone in the fraction less than 4 mm in grain size and the maximum occurrence of dolomite in the fraction with grain sizes between 4 and 10 mm. It appears that grain size is determined to some extent by rock type.

Description of Rock Samples

The percentages of the various rock types (in terms of weight) making up the portion of each dredge sample consisting of material greater than 3 mm in grain size, are given in Table 1. Gravels with diameters greater than 20 mm are described in some detail below. The aim of this descriptive analysis of the samples is to attempt to obtain a more positive identification of their source areas.

Limestone: The limestones in Samples 1 and 2 are all of the same type. Hand specimens are light gray to light blue in color. Under the microscope, these limestones are found to be true calcilutites (made up of calcareous rock flour) with some patches consisting of mosaics of coarser, recrystallized calcite. Some shell fragments and crinoid ossicles constitute a small proportion of the rock. Specks of limonite produced by alteration of pyrite can be seen in some of the thin-sections examined under the microscope.

A light gray to yellow limestone pebble found in Sample 3 contains a large number of shell fragments in a calcilutite matrix. Among the fragments are brachiopods (tentatively identified as chonetids and productids), gastropods, crinoid ossicles, and some bryozoans. The limestone is probably Permo-Carboniferous in age (i.e., formed 205–255 million years ago).

A yellow-gray limestone unlike any in the other samples was found in Sample 6. This limestone, a calcilutite with some small recrystallized areas, contains many poorly preserved fossils—probably brachiopod shells and foraminiferal tests—and a few pyrite crystals. The presence within it of small limestone mud pebbles suggests that this limestone was formed under shallow-water conditions.

Dolomite: The dolomite found in all of the dredge samples appears to be of the same type. It is white or white-brown in color and is invariably recrystallized into a fine- to medium-grained dolomite marble with crystals arranged in a mosaic pattern. In two specimens, a preferred orientation of the crystal axes was noted, suggesting that the rock has undergone some tectonic deformation. Fine-grained, clastic quartz grains are interspersed in places within the dolomite or form small lenses of sandstone. Fossil remains are rare and those found are not identifiable.

It is likely that the dolomites found in these samples dredged from the bottom of the Arctic Ocean are derived from an extensive series of sedimentary rocks originally deposited under shallow-water conditions, and that the dolomite layers may

Table 1. Weight Percentages of the Various Rock Types in Station Alpha Dredge Samples.

No.	Location	Depth (Meters)	Fraction >3 mm	Fraction >20 mm	Rock Types* (%) Ls	Dol	Ss & Sh	Ig & Met
1	83° 59′ N 151° 44′ W	2590	135 gm	None	15	26	50	9
2	84° 09′ N 150° 23′ W	2490	1029 gm	253 gm	32	36	27	5
3	84° 16′ N 149° 11′ W	1658	30 gm	None	13	29	43	15
4	84° 22′ N 148° 51′ W	1776	23 gm	None	21	22	44	13
5	84° 27′ N 148° 28′ W	1700	3307 gm	2698 gm	11	33	54	2
6	84° 33′ N 146° 24′ W	2201	93 gm	None	14	42	36	8
7	84° 30′ N 145° 00′ W	2294	156 gm	None	16	45	35	4
8	84° 31′ N 143° 30′ W	2118	None	103 gm	0	100	0	0
9	85° 01′ N 138° 00′ W	1840– 1910	8739 gm	8692 gm	8	5	3	84

* Ls = limestone; Dol = dolomite; Ss = sandstone; Sh = shale; Ig = igneous; Met = metamorphic

once have been interbedded with layers of sandstone.

Sandstone and Shale: A single sandstone pebble found in Sample 1 is dark gray in color and consists of angular quartz grains, .01–.05 mm in diameter, in a fine-grained cementing matrix of mica and chlorite. The quartz grains show signs of having been subjected to strain at some time in the past.

One large sandstone specimen, in which subangular .02–.1 mm quartz grains are cemented together by a matrix of calcareous material, was present in Sample 3. The specimen is highly fossiliferous, and a number of brachiopods and bryozoans, indicating a Permo-Carboniferous age (more likely Permian) for the specimen, have been identified. Crinoid ossicles and gastropod fossils also occur.

Another sandstone specimen, a dark-green, graywacke-type rock with wisps of black shale parallel to the bedding planes, contains very-well-rounded quartz grains many of which show well-developed strain lamellae. The mica matrix of this sample also exhibits "flow structure" deformation, and low-grade metamorphism is thus likely. A similar sandstone pebble shows a greater degree of metamorphism, with interpenetrating grain boundaries, and other sandstone specimens appear relatively unaltered. A pink specimen found in Sample 6 consists of close-fitting, well-rounded quartz grains cemented with calcite.

One specimen of conglomerate, consisting of well-rounded, dark-gray to black chert pebbles and a few quartzite pebbles in a matrix of quartz sandstone and chert, was found. A loose piece of chert in Sample 5 contains a large amount of calcareous organic detritus and a few grains of quartz and of glauconite. (Glauconite, a green hydrous potassium-iron silicate closely related to mica, commonly occurs in sediments of marine origin.)

Igneous and Metamorphic Rocks: Sample 9 consists mostly of a single large diabase cobble weighing 7300 gms. Under the microscope, it is seen to be made up of a large mass of lath-shaped crystals of plagioclase feldspar, with an intergrowth of large plates of pyroxene. Some magnetite, amphibole, and grains of quartz are also present. A metamorphic pebble, composed of chloritoid schist, was found in Sample 1.

Core Samples: In addition to those found in abundance in the materials dredged from the ocean floor, pebbles were also obtained from various depths beneath the floor in core samples. The pebbles found in the cores are generally small—the largest was 17 mm in diameter—and in many respects they resemble those in the dredge samples.

One core contained a pebble of basic igneous rock at a depth of 115 cm, and a piece of metamorphic rock—a sericite schist—was found at a depth of 46 cm in another. A light-gray limestone pebble with some shell fragments (possibly brachiopods) was discovered 46 cm down in a core; a dolomite pebble similar to those in the dredge samples occurred at 64 cm in another core; and a fine-grained sandstone pebble was found at 69 cm in still another.

Comparisons with Soviet Samples

Comparison of the Station Alpha data with data from Soviet drifting station NP-2 (1954–1955) shows that the composition of the bottom gravels in this portion of the Arctic Ocean is fairly uniform. The Russian dredge samples, though taken at a distance of 200 to 600 miles from those of Station Alpha, are quite similar in relative composition to the Station Alpha gravels. (See Figure 2 for a graphical comparison.) However, no agreement is seen between the dredged gravels obtained by stations Alpha and NP-2 and rocks found on the surface of T-3, or Fletcher's Ice Island, on which US-IGY Drifting Station Bravo was situated. (Fletcher's Ice Island is a large ice island thought to have broken away from the Ellesmere Ice Shelf; see *Bulletin Nos. 24* and *27*.)

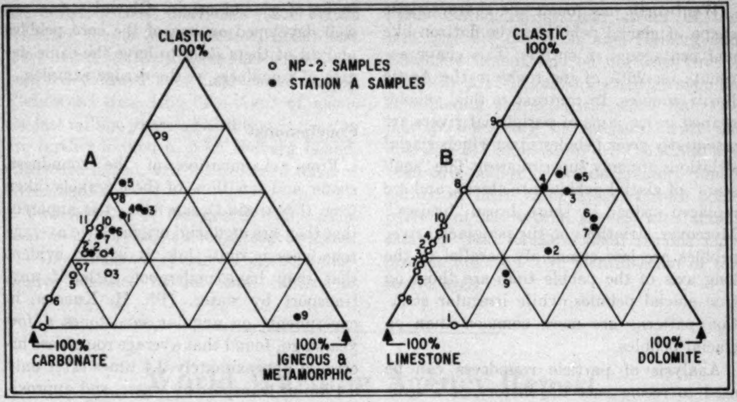

Fig. 2. *Comparison of Percentages of Various Rock Types, by Weight, in Dredge Samples from Drifting Station Alpha and from NP-2. Diagram A compares carbonate-igneous-clastic composition, showing a close similarity between Station Alpha and NP-2 samples; diagram B compares limestone-dolomite-clastic composition, for which agreement between samples collected by the two stations is not as good. While the proportion of carbonates to clastics is about the same in both sets of samples, Station Alpha carbonates have a relatively greater amount of dolomite and NP-2 carbonates are almost entirely limestones.*

Manganese Coatings and Worm Tubes

All specimens of the dredged rocks larger than 20 mm, and a large number of the smaller pebbles, are partly covered with a thin (probably less than 0.001 mm), black manganese coating. The coating is restricted to portions of the pebbles that were exposed to the sea water; the portions buried in mud are not coated.

Examination of 18 pebbles oriented approximately in their original positions, as indicated by the boundaries of the manganese coatings, showed that the average ratio of depth of the buried portions to height of the exposed portions is about 1:3. This ratio does not correlate with rock size. Similar manganese coatings occur on the pebbles found in core samples, indicating that they too were at one time exposed to sea water.

The manganese-coated portions of many of the dredged rocks are encrusted with worm tubes, but no living specimens were found in any of the worm tubes and many of the tubes are themselves coated with manganese.

Surface Texture and Roundness of Pebbles

Nearly half of the 27 rocks larger than 20 mm in diameter distinctly show striations resulting from glacial action. C. K. Wentworth in 1936 found a similar proportion of striated rocks in moraine deposits left by glaciers. As expected, limestones in the dredge samples usually have the best preserved striations. Striations on dolomites are relatively short, coarse, and poorly preserved. Some of the limestone pebbles have highly polished surfaces. Under the microscope, the polish was seen to be abrasive and to contain many minute scratches in the direction of the large striae.

Wentworth has found the characteristic shape of glacial pebbles to be flatiron-like and pentagonal in outline. This shape accounts for 26% of the rocks in the Arctic Basin samples. In contrast to this, pebbles shaped in ice jams of periglacial rivers are essentially river pebbles upon which glacial striations are only superimposed. The "snub scars" of glacial pebbles are absent, and are replaced instead by short, broad "bruises." Moreover, striations on the periglacial river pebbles are less commonly parallel to the long axis of the pebble than are those on true glacial pebbles, while irregular striation patterns are more common than on glacial pebbles.

Analysis of particle roundness can be used to reconstruct the history of a sediment. A large number of factors influence rounding, including two unknown quantities of particular importance—the environment in which rounding took place and the length of time the sediment was exposed to that environment. Several different roundness coefficients have been developed by various investigators.

From each dredge sample, 25 limestone and 25 dolomite pebbles ranging in size from 2 to 10 mm were chosen for roundness measurements. In most water-transported sediments, a relationship exists between the size of the pebbles and their roundness, and thus only pebbles of a uniform size group are strictly comparable. Whether a similar relation exists for glacial material is not known. A comparison of three size ranges of dolomite pebbles from dredge Sample 2 showed an apparent decrease of roundness with increase in grain size, but this increase is not statistically significant. Also, a comparison between dolomite and limestone pebbles showed no significant difference in roundness. In general, the roundness of the Station Alpha material agrees well with the roundness of glacial tills, as found previously by various authors.

Although the cores yielded only five pebbles for examination, these too appear to be of glacial origin. Glacial striae are well developed on one of the core pebbles and all of them seem to have the same degree of roundness as the dredge samples.

Conclusions

From examination of the roundness, shape, and striations of these gravels taken from the Arctic Ocean floor, it is apparent that they are of glacial origin. Since average roundness is quite low, it is also evident that they have undergone little, if any, transport by water. (Ph. H. Kuenen, in experiments on angular sandstones a few years ago, found that average roundness increased approximately 2.4 times after only 0.4 km of transport by water, and approximately 5 times after 3 km of transport. Observations by Wentworth, in 1922, showed that a travel distance of only 0.35 miles was sufficient to remove striae from hard limestones and greenstones.)

Thus, it appears that these Arctic Basin gravels have been ice-rafted from a coast on which active glaciers reached the shore. It is probable that the material was transported in icebergs that had calved directly from the glaciers. Also, at least part of the material was frozen into the bottom of either grounded icebergs or sea ice. A. Clarke, Jr., has studied the molluscan shells from these same dredge samples and concludes that, since they are shallow-water species, many of the shells have been transported from their source areas to the deep-water locations at which they were found, undoubtedly after having been picked up by grounded ice in shallow water near the shore.

Oceanic circulation in this area (see *Bulletin No. 24*) and the extent of Pleistocene glaciation considerably limit the possible source areas for these gravels. The circulation pattern in the North Canadian Basin makes it likely that the material was obtained from the northern coast of Greenland, the Canadian Arctic Archipelago, or the northern coast of Alaska. (See Figure 1.) Since the northern coast of Alaska and most of the northern Canadian islands are believed to have been unglaciated during Pleistocene time (the "Ice Age" of about the last million years), possible source areas are further limited to Axel Heiberg Island, Ellesmere Island, and the northern coast of Greenland.

Two features of the gravel composition tend to support this choice of source areas: (1) One sandstone specimen has been definitely identified by its fossil content as Permo-Carboniferous, and strata of the same age are found on Axel Heiberg and Ellesmere islands and on northern Greenland. (2) All Station Alpha dredge samples contained a characteristic white dolomite marble that may be identical with the dolomite of Cambrian to pre-Cambrian age (430–510 million years or greater) found earlier in these same areas. Future comparison of the bottom gravels with actual samples from Arctic coastal regions may provide more positive identification of the source area.

World Warning Agency Report

October 1 - December 31, 1960

This report, one of a series issued periodically during and following the IGY and IGC-59 periods, is based on (i) the final quarterly report for 1960 by the World Warning Agency (AGIWARN), originally established as part of the IGY World Days Program, and (ii) compilations of Solar-Geophysical Data *for the above period, issued by the Central Radio Propagation Laboratory of the National Bureau of Standards in November and December 1960 and January 1961.*

AGIWARN activities are supervised by J. M. Weldon. Another report in this issue of the Bulletin *outlines the World Days plan for 1961–62 and provides additional information about the International World Days Service and related activities.* Bulletin No. 43 *contains a report on major flares, geomagnetic disturbances, world-wide Geophysical Alerts, and Special World Intervals for the third quarter of 1960.*

Of 12 geomagnetic disturbances recorded during the final quarter of 1960, Advance Alerts were issued for 7 and world-wide Geophysical Alerts were issued for 11. Storms for which Advance Alerts were not issued either were too minor to meet Alert criteria or began only a few hours before 1600 UT and therefore could not be announced effectively by a world-wide Alert.

No world-wide Alert was issued for the very minor October 4 disturbance which ended several hours before the 1600 UT issue time. Two world-wide Alerts issued in connection with the intense solar activity associated with the great geomagnetic storm that began November 12 were unusual in that both announced a cosmic-ray increase. Only one cosmic-ray increase Alert has ever been issued before by AGIWARN. In addition, the world-wide Alert issued on November 15 referred to a sudden-commencement-type resurgence of the November 12 magnetic storm. (A more complete discussion of these events is given below.)

Seven of the magnetic storms recorded during the quarter began gradually. None of these was readily predictable on the basis of the tendency for magnetic storms to recur at 27-day intervals, although some appeared to fit vague patterns of recurrence. It may be a year or more before the period of the solar cycle is reached when the 27-

day-recurrence pattern becomes distinct enough to be used effectively in forecasting actual disturbances. Of special interest is the storm that began gradually on October 5. It was unusually severe and lasted longer than any storm in the past two years. Research groups in Regional Warning Centers as well as in CRPL have given this storm special emphasis in their studies.

Of five sudden-commencement-type storms recorded during the quarter, three were preceded by observable solar events and were predicted by AGIWARN. The other two, which occurred on October 24 and November 24, were not expected. Certain statistical sun-earth relationships might have been applied toward successful prediction of the former. The latter, except for its sudden beginning, might be considered as a recurrence of a storm that first occurred 27 days earlier.

List of Major Events

The following is a list of major solar flares, geomagnetic disturbances, and worldwide Geophysical Alerts and SWI issued by AGIWARN during the last quarter of 1960 (October 1–December 31):

Sep	30	13xx*	Magnetic storm begins
Oct	1	1600	Alert issued (MAGSTORM)**
	2	19xx	Magnetic storm ends
	4	14xx	Magnetic storm begins
	5	10xx	Magnetic storm ends
		19xx	Magnetic storm begins
	6	1600	Alert issued (MAGSTORM); auroras probable
			SWI starts†
	8	2359	SWI finishes
	14	2033	Class 3 flare
	24	1450	Severe magnetic storm begins
	25	1600	Alert issued (MAGSTORM)
	29	1026	Class 3 flare; G-SWF††
Nov	1	09xx	Severe magnetic storm ends
	3	22xx	Magnetic storm begins
	4	1600	Alert issued (MAGSTORM)
	5	09xx	Magnetic storm ends
		1250	Class 3 flare
	6	1752	Class 3 flare; S-SWF
	10	1009	Class 3+ flare; S-SWF
	12	1315	Class 3+ flare; S-SWF
		1350	Very severe magnetic storm begins (A-index of 275, highest ever recorded by AGIWARN, reached on November 13)
		1600	Alert issued (MAGSTORM)
			SWI starts
	13	1600	Alert issued (COSRAY INCREASE)
	14	2359	SWI finishes
	15	1600	Alert issued (COSRAY INCREASE; MAGSTORM)
			SWI starts
	17	21xx	Very severe magnetic storm ends
		2126	Class 3 flare
		2359	SWI finishes
	20	1955	Class 3 flare; S-SWF
	21	04xx	Magnetic storm begins
		1600	Alert issued (MAGSTORM)
	22	13xx	Magnetic storm ends
	24	2053	Magnetic storm begins
	25	1600	Alert issued (MAGSTORM)
	26	15xx	Magnetic storm ends
	30	1910	Severe magnetic storm begins
Dec	1	1600	Alert issued (MAGSTORM)
	3	00xx	Severe magnetic storm ends
	5	1825	Class 3+ flare; S-SWF
	7	1804	Magnetic storm begins
	8	1600	Alert issued (MAGSTORM)
		16xx	Magnetic storm ends
	15	07xx	Magnetic storm begins
	16	1600	Alert issued (MAGSTORM)
		16xx	Magnetic storm ends
	27	03xx	Magnetic storm begins
		1600	Alert issued (MAGSTORM)
	28	21xx	Magnetic storm ends

Notes:

* "xx" indicates gradual beginning or ending of a disturbance, following the hour indicated, such that the precise moment could not be determined.

** No ending times for Alerts are issued; this is left to the discretion of the individual observatories. Capitalized acronyms indicate the kind of Alert issued: MAGSTORM = magnetic storm; COSRAY INCREASE = cosmic-ray increase.

† SWI's start at the time the associated Alert is issued (1600 UT) and finish at the end of the day indicated (2359 UT).

†† G-SWF = gradual ionospheric disturbance with irregular fading in either drop-out or recovery, or in both; S-SWF = sudden short-wave fadeout and gradual recovery.

Intense Solar-Terrestrial Activity During the Period November 5–17

Because of the extremely interesting solar activity and corresponding terrestrial effects that occurred between November 5 and November 17, this period is discussed below in some detail (with limitations imposed, however, by the preliminary nature of the solar and geophysical data available at this time).

On November 5, a medium-sized calcium plage rotated onto the sun's east limb at about 20° North Latitude. By November 6, a giant complex sunspot group was observed accompanying the plage. (The plage had been visible during the previous solar rotation and had been relatively inactive throughout its transit until nearing the west limb, when, during the last two days of observation, a large spot-group had developed.)

By November 8, the 20-cm radio-noise flux had increased greatly, and 107-mc radio-noise outbursts classified as major and major+ had been recorded, with the large sunspot region as the likely source. (A major burst is an outburst of solar radio noise of large amplitude and longer than average duration; the designation major+ refers to a major burst followed by another, comparable rise in noise flux.)

On November 10 at 1009 UT, Wendelstein Observatory (Germany) observed an importance-3 flare of very long duration in the growing region. This flare was accompanied by several major and major+ solar-noise outbursts on various frequencies. Huancayo Observatory (Peru) reported observing an importance-2 flare in the same location about four hours later. Intermittent observations at McMath-Hulbert Observatory (Michigan) indicated that Huancayo may have witnessed the latter stages of the 1009 UT flare. Severe short-wave radio fadeouts were experienced at several stations associated in time with the flare event. However, the observatory at College, Alaska, reported no discernible polar-cap radio absorption.

On November 11, reports of other severe short-wave fadeouts were received; the most severe, occurring near 0300 UT that day, was accompanied by further major solar-noise bursts and by very large disturbances recorded by radio spectrographs in Sydney, Australia. With the above information available, the North Atlantic Radio Warning Service issued a Special Disturbance Warning (at 2038 UT November 11) predicting that a radio and geomagnetic disturbance would begin on November 12.

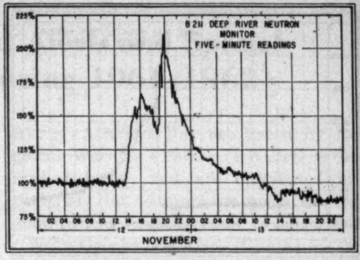

Fig. 3. *Cosmic-Ray Increase on November 12–13, 1960, as Shown by Neutron-Monitor Record from the Canadian Station at Deep River, Ontario. A peak increase of over 100% was reached at about 2000 UT on November 12, followed by a drop to values approximately 10–15% below the mean after about 1300 UT on the 13th. This decrease continued until the 15th, when another large increase occurred (see Fig. 4). Record submitted to CRPL by H. Carmichael and J. Steljes, Atomic Energy of Canada, Ltd.*

At 1325 UT November 12, McMath-Hulbert observed an importance-3+ flare in the same solar region, then just east of the sun's central meridian. The flare was also observed by the Sacramento Peak (New Mexico) and Nederhorstdenberg (Netherlands) observatories. AGIWARN distributed the flare information via special telegram and accompanying an Advance Solar Flare Alert. At 1350 a magnetic storm began suddenly and at 1600 UT a worldwide Magnetic Storm Alert containing the decision to begin an SWI was issued by AGIWARN.

Later, on the 12th, many reports of short-wave fadeouts and solar-noise outbursts were received, all in time association with the great flare. Also received was a report from the University of Chicago of a strong cosmic-ray increase beginning about 1345 UT (see Fig. 3), and College reported the

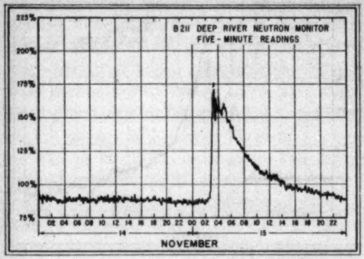

Fig. 4. *Cosmic-Ray Increase on November 15, 1960, as Shown by Deep River Neutron-Monitor Record. A peak increase of about 75% was reached at approximately 0300 UT, followed by a decline to about 10–15% below the mean toward the end of the day. Record submitted to CRPL by H. Carmichael and J. Steljes.*

beginning of strong polar-cap absorption at 1700 UT. Both the polar-cap absorption and the cosmic-ray increase were still in progress at 2100 UT. The IZMIRAN (USSR) and Kakioka (Japan) observatories both reported the magnetic storm via Advance Magnetic Storm Alerts. The storm reached great severity in the early hours of the 13th, and by late that day an A-index of 275, the highest on record at AGIWARN, had been reached. The SWI begun by AGIWARN at 1600 UT November 12 was continued via a World Wide Alert at 1600 UT November 13, along with notification of the cosmic-ray increase.

The next major flare activity in the region was observed November 14. Mitaka Observatory (Japan) reported a 2+ flare at 0246 UT, and observation of three class-2 flares, at 0015 UT, 1836 UT, and 2118 UT, were made at Hawaii, Sacramento Peak, and Burbank, California, respectively. The 2+ flare was accompanied by major radio-noise outbursts on several frequencies. The SWI continued through the 14th, while the magnetic storm continued but decreased in intensity.

At 0207 UT November 15, Mitaka observed another 3+ flare in the same solar region, then about three days east of the sun's central meridian. Many major radio-noise outbursts, over a wide range of frequencies, were recorded in time association with the event. The University of Chicago reported a 50% increase in cosmic radiation between 0200 UT and 0300 UT (see Fig. 4), and riometers at College showed another intense polar-cap-absorption event by 1000 UT. A Cosmic Ray Increase Advance Alert was issued by AGIWARN. Magnetographs at AGIWARN, which had become relatively quiet between 0300 and 1200 UT on November 15, showed a marked sudden-commencement-type resurgence at 1305 UT. The world-wide Alert issued at 1600 UT referred to the Cosmic Ray increase at 0200 UT and to the marked increase in magnetic activity at 1305 UT, and began another Special World Interval that was continued through November 17.

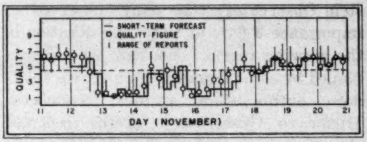

Fig. 5. *Radio-Quality Disturbances, November 12–19, 1960, in the North Atlantic Region. The chart compares actual quality figures with the short-term forecast, using a scale ranging from 1 to 9 (1 = useless, for medium-powered radio, 3 = poor, 5 = fair, 7 = good, and 9 = excellent). Prepared by CRPL, NBS, at Boulder, Colorado.*

No further reports of major flare activity were received and the solar region involved, still containing a large plage and a sunspot group, was rotated beyond the sun's west limb on November 19. The magnetic disturbance ended on November 17, late in the day. During this series of events, short-wave radio-propagation conditions became disturbed during the last half of November 12 (see Fig. 5), remained severely disturbed through November 16, and recovered to near normal by November 19.

Plan for Geophysical Alerts and Special World Intervals during 1961-1962

The following material is based on an information circular issued by the World Warning Agency (AGIWARN) for distribution to all geophysical stations and observatories of nations participating in the continuing international program of World Days and Communications, begun during the IGY and now known as the International World Days Service (IWDS). AGIWARN was set up during the IGY by the Special Committee for the IGY (CSAGI) of the International Council of Scientific Unions (ICSU).

The circular describing the new plan for Geophysical Alerts and Special World Intervals (SWI) was issued by James M. Weldon, Head, AGIWARN, under the general supervision of J. V. Lincoln in association with A. H. Shapley, IWDS Spokesman. Questions concerning the plan should be addressed to the IWDS World Warning Agency at the address below. (The World Days programs for the IGY and IGC-1959 are described in IGY Bulletin Nos. 5 *and* 23, *respectively;* Bulletin No. 42 *contains a report on the International Geophysical Calendar for 1961, and other* Bulletins *review program results on a quarterly basis.)*

The plan described in this report for Geophysical Alerts and Special World Intervals during the period 1961–62 supersedes previous plans established for the IGY, IGC-59, and 1960. The new plan will remain in effect at least through 1962, although some minor modifications may be needed as a result of changes in the level of solar activity.

Under the 1961–62 plan, an *Alert* is issued as soon as possible after an exceptional solar or geophysical event has occurred or has started, and serves to aid the observing programs at geophysical stations. Advance Alerts (ADALERT's) are issued by Regional Warning Centers (RWC's), as described below, and are distributed immediately by telegram or radio to local geophysical stations and to the other RWC's. Geophysical Alerts (GEOALERT's) are for world-wide distribution and are issued by the World Warning Agency. There are four different kinds of Alerts—Solar Flare, Magnetic Storm, Cosmic Ray, and Aurora, with specific criteria for each.

Special World Intervals (SWI's) are declared only by AGIWARN, and the pertinent information is included in the GEOALERT message. Many geophysical stations carry out special observing programs during SWI's. (Note: Words shown entirely in capital letters—i.e., ADALERT, GEOALERT, etc.—are abbreviations for use in telegraphic messages; sample messages are shown below.)

It is assumed that geophysical stations interested in receiving Alerts have communications channels by telegraph or radio broadcast with one of the four RWC's or with Associate RWC's. Alternatively, geophysical stations may have access to an outlet of the meteorological telecommunications network coordinated by the World Meteorological Organization (WMO). However, only the GEOALERT (i.e., international) messages are carried on this network. Geophysical stations that do not have suitable communications channels should make arrangements with the appropriate RWC or with AGIWARN.

Advance Alerts (ADALERTS)

Any Regional Warning Center may issue an "Advance Alert" as soon as the outstanding solar or geophysical phenomenon is recognized and the RWC is satisfied that it meets the stated criteria. The Advance Alert message should be distributed as promptly as is practical within the RWC region, and should also be sent promptly to each of the other RWC's for their information and action in case the event was missed by stations in their regions. These prompt Advance Alert messages serve both to aid the observing programs at individual geophysical stations and to provide advice to the World Warning Agency on the declaration of world-wide Geophysical Alerts.

Criteria: The RWC's use the following criteria for the four kinds of Advance Alerts:

Solar Flare (SOFLARE) Alert—issued when a solar flare of median importance (2+), or greater, has been reported; there will be only one alert issued per flare, and only one a day at most.

Magnetic Storm (MAGSTORM) Alert—issued whenever a significant magnetic storm (K figure of 5 or greater at a middle-latitude station) has begun.

Cosmic Ray (COSRAY) Alert—issued whenever a very outstanding change in cosmic-ray flux (either an increase or a decrease) has been observed.

Aurora Alert—issued whenever a magnetic storm in middle latitudes has reached a K-figure of at least intensity 7 (AURORA PROBABLE) or whenever selected auroral stations report the presence of outstanding auroras (AURORA OBSERVED).

Message Forms: The texts for Advance Alert messages are in the standard forms shown in the following samples, and include identification of the stations reporting the event, nature of the event, and time of the event:

(a) ADALERT KOKUBUNJI SOFLARE 280010Z (Solar flare event of importance 2+ or greater observed by Kokubunji at 0010 UT on 28th day of month.)

(b) ADALERT NIZMIR MAGSTORM 291900Z (NIZMIR recorded beginning of significant magnetic storm—K-figure of 5 or greater—at 1900 UT on 29th day of month.)

(c) ADALERT ZUGSPITZE COSRAY DECREASE 061130Z (Nominal time of unusual cosmic-ray-flux decrease recorded at Zugspitze was 1130 UT on the 6th day of month.)

(d) ADALERT CORNELL AURORA OBSERVED 070230Z (Outstanding aurora observed by Cornell University, USA, at 0230 UT on the 7th day of month.)

(e) ADALERT AGIWARN AURORA PROBABLE MAGSTORM 070230Z (Beginning of significant magnetic storm—K-figure of 7 or greater—recorded at AGIWARN at 0230 UT on 7th day of month; auroral displays should be expected.)

GEOALERTS, Including SWI

Only the World Warning Agency issues declarations of world-wide Geophysical Alerts and of Special World Intervals. These declarations are made at 1600 UT on any day when the course of solar and geophysical activity makes them appropriate. Declaration of a world-wide Alert is made after consideration of Advance Alerts issued by one or more RWC's, which also provide advice concerning inclusion of SWI's in the declarations. All messages begin with the words "GEOALERT NOxxx," where "NO" is the message abbreviation for "number" and xxx is the serial number of the GEOALERT message issued.

GEOALERTS: World-wide Geophysical Alerts may be declared in one or more of the following categories: Magnetic Storm, Cosmic Ray Increase, and Aurora. The criteria are the same as those given for Advance Alerts and the Geophysical Alert message is in a standard text specifying the nature and time of the event. Samples of possible messages are as follows:

(a) GEOALERT NO135 MAGSTORM 051000Z (The 135th world-wide Geophysical Alert issued; a significant magnetic storm—K-figure of 5 or greater—started at 1000 UT on 5th day of month.)

(b) GEOALERT NO015 AURORA PROBABLE MAGSTORM 100716Z (The 15th world-wide Geophysical Alert issued; a magnetic storm with K-figure of 7 or greater started at 0716 UT on 10th day of month; auroral displays should be expected.)

(c) GEOALERT NO010 COSRAY INCREASE 061825Z (The 10th world-wide Geophysical Alert issued; nominal time of an unusual cosmic-ray-flux increase was 1825 UT on 6th day of month.)

(d) GEOALERT NO022 AURORA 120940Z (The 22nd world-wide Geophysical Alert issued;

outstanding aurora observed at 0940 UT on 12th day of month; stations to west should expect to observe aurora.)

Special World Intervals: A GEOALERT message is issued to start an SWI, messages are issued every day thereafter to continue it, and another is issued to finish the SWI. An SWI usually lasts one or two days. The SWI may be based on a prediction that important geomagnetic and associated activity will start in the next few hours; in this case, the words "PREDICTED SWI" will be used in the message until the activity actually starts. For an SWI declared when important geomagnetic and associated activity is already in progress, the term "SWI" will be used alone.

An SWI is considered to start when the "START SWI" or "START PREDICTED SWI" message is received by a geophysical station. The SWI is considered over by 2359 UT of the day the "FINISH SWI" or "FINISH PREDICTED SWI" message is issued. The following are samples of possible messages (explanations of messages are similar to those above, but include SWI information; additional comments are made where needed):

(a) GEOALERT NO031 MAGSTORM 051000Z START SWI 051600Z

(b) GEOALERT NO032 CONTINUE SWI 061600Z (Special World Interval continues for another day.)

(c) GEOALERT NO033 FINISH SWI 072359Z

(d) GEOALERT NO050 START PREDICTED SWI 101600Z (Stations should conduct the SWI program appropriate to their geophysical disciplines; a major geomagnetic storm is predicted.)

(e) GEOALERT NO051 MAGSTORM 102314Z CONTINUE SWI 111600Z (Significant magnetic storm started at 2314 UT on the 10th day of month; thus, predicted SWI started by GEOALERT NO050 was successful and the SWI declared on 10th day of month at 1600 UT is to continue on the 11th.)

(f) GEOALERT NO052 FINISH SWI 122359Z

(g) GEOALERT NO051 CONTINUE PREDICTED SWI 111600Z (Major geomagnetic storm still predicted.)

(h) GEOALERT NO051 FINISH PREDICTED SWI 111600Z (There is no longer a high probability that a major geomagnetic storm will begin; therefore, finish SWI programs upon receipt of message.)

Communications Channels for GEOALERTS

Meteorological Telecommunications Network: GEOALERT messages are delivered at 1600 UT to the WMO meteorological telecommunications network at Washington, D. C. The message is then distributed throughout the world in accordance with plans developed by WMO. Geophysical stations may make arrangements with nearby meteorological stations for receiving the messages. On days when no GEOALERT message is issued, the meteorological network will carry the message IGC KWWA XX/XXXXZ NEGATIVE.

Distribution by Regional Warning Centers: AGIWARN also sends GEOALERT messages at 1600 UT by telegram to each RWC. Further distribution within each region then takes place according to plans made by the RWC for that region.

Radio Broadcasts: The general content of GEOALERT messages is indicated by a symbol broadcast repeatedly in Morse code on National Bureau of Standards radio stations WWV and WWVH twice each hour. Beginning at 1604 UT, the symbol is first broadcast at 4 and 34 minutes past each hour on WWV, and beginning at 1714 it is also broadcast at 14 and 44 minutes past each hour on WWVH. Similar broadcasts are made in the various RWC regions. The symbols, *sent in very slow and deliberate code,* are as follows:

AGI EEEEE
·– ––· ·· · · · · · state of "No World-wide Alert"

AGI AAAA
·– ––· ·· ·– ·– ·– ·– state of "World-wide Alert"

AGI (3 extra-long dashes)
·– ––· ·· —— —— —— SWI in progress

Warning Centers

The addresses of AGIWARN and of the various RWC's are given below to enable geophysical stations to establish suitable communications channels:

IWDS World Warning Agency

AGIWARN
Box 178, Ft. Belvoir, Virginia, USA
Washington, D. C., SOuth 5-6411 or SOuth 5-8436
Attn: James M. Weldon

Regional Warning Centers

Western Europe:

Radio Receiving Station NERA
Nederhorst den Berg
Netherlands
Attn: L. D. De Feiter

Jours Mondiaux
196, rue de Paris
Bagneux (Seine), France
Attn: A. Delouf

Fernmeldtechnisches Zentralamt (FTZ)
Rheinstrasse 110, Darmstadt
Federal German Republic
Attn: G. Richter

Eurasia:

Institute of Terrestrial Magnetism,
Ionosphere and Radio Propagation
(IZMIRAN)
Moscow, USSR
Attn: L. N. Liakhova

Western Pacific:

Radio Research Laboratories
Kokubunji, P.O., Koganei-shi, Tokyo, Japan
Attn: T. Takiguchi

Western Hemisphere:

IWDS World Warning Agency (AGIWARN)
(Details same as above.)

Associate Regional Warning Centers

Australasia:

Ionosphere Prediction Service
5 Hickson Road, Millers Point
Sydney, N.S.W. Australia
Attn: F. E. Cook

Alaska:

North Pacific Radio Warning Service
National Bureau of Standards
Box 1119, Anchorage, Alaska
Attn: L. W. Honea

Sweden:

The Royal Board of Swedish Telecommunications
Brunkebergstorg, 2
Stockholm 16, Sweden
Attn: Sven Gejer

Coordination and Administration

The 1961–62 World Days plan is coordinated by IWDS of ICSU and administered by the International Scientific Radio Union (URSI). The members of the IWDS Steering Committee are A. H. Shapley, IWDS spokesman (URSI); M. Nicolet (International Union of Geodesy and Geophysics); J. F. Denisse (International Astronomical Union); and R. Coutrez, Secretary (URSI, 7 Place Emile Danco, Brussels). The plan was worked out jointly with the URSI Central Committee on Ursigrams (CCU), which coordinates the telegraphic collection, interchange, and distribution of summaries of current solar and geophysical data. Members of the CCU, and the regions they represent, are N. V. Pushkov (USSR), Eurasia; R. L. Smith-Rose (UK), Western Europe; H. Uyeda (Japan), Western Pacific; A. H. Shapley (USA), Western Hemisphere; and R. Coutrez, Secretary (URSI).

Arrangements for the distribution of GEOALERT messages were worked out in cooperation with the WMO. The re-introduction of "PREDICTED SWI" into the plan for 1961–1962, which had been omitted in the 1960 plan, was decided on at a joint IWDS-CCU meeting in London, September 12, 1960.

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SCIENCE IN SPACE

A volume entitled *Science in Space* has been prepared by members of the Space Science Board of the National Academy of Sciences-National Research Council. The book, consisting of 20 chapters organized into several major categories of space research, was edited by Lloyd V. Berkner (Chairman) and Hugh Odishaw (Executive Director) of the Board.

Science in Space was published by McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York. The 439-page volume contains 106 illustrations and tables. It is priced at seven dollars. The chapters and their authors are as follows:

Part 1—A General Review

1. Dimensions and Problems, L. V. Berkner and Hugh Odishaw
2. Results of Experiments in Space, Bruno Rossi and Robert Jastrow

Part 2—Gravity

3. The Nature of Gravitation, R. H. Dicke

Part 3—The Earth

4. Knowledge of the Earth from Space, Harrison Brown
5. Some Aspects of Geodesy, George P. Woollard
6. Meteorology, Harry Wexler
7. Rocket Research and the Upper Atmosphere, W. W. Kellogg
8. Satellites and the Upper Atmosphere, A. H. Shapley and O. G. Villard, Jr.

Part 4—The Moon and the Planets

9. The Moon, H. C. Urey
10. The Planets, H. C. Urey

Part 5—Fields and Particles in Space

11. Physics of Fields and Energetic Particles in Space, J. A. Simpson
12. The Interplanetary Gas and Magnetic Fields, E. N. Parker
13. The Acceleration and Propagation of Particles within the Solar System, J. A. Simpson
14. Solar Modulation of Cosmic Radiation and Other Energetic Particles Reaching the Earth, J. A. Simpson
15. The Geomagnetically Trapped Corpuscular Radiation, James A. Van Allen
16. On Particles and Fields Pertinent to Auroral Theory, Joseph W. Chamberlain

Part 6—The Stars

17. The Sun, Leo Goldberg and E. R. Dyer, Jr.
18. Galactic and Extragalactic Astronomy, Leo Goldberg and E. R. Dyer, Jr.

Part 7—The Life Sciences

19. The Biological Sciences and Space Research, Joshua Lederberg and H. Keffer Hartline
20. Exobiology: Experimental Approaches to Life beyond the Earth, Joshua Lederberg

Part 8—Appendix

The scientific knowledge and concepts on which *Science in Space* is based are derived from the work of a broad spectrum of American and foreign scientists. Detlev W. Bronk, President of the National Academy of Sciences, sat with the Board during critical discussions, contributing advice and guidance. All members of the Space Science Board and of its committees have contributed to preparation of the volume through discussion, criticism, and editorial comment. In addition, many scientists outside the formal organization of the Board have given freely of their time and assistance.

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IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation–1959 as related primarily to United States programs. The Bulletin *also reports on international programs in geophysics and space science that have grown out of the IGY, and on their results.*

Explorer X Magnetic-Field and Plasma-Probe Satellite

The National Aeronautics and Space Administration's Goddard Space Flight Center, at 10:17 am EST on March 25, 1961, launched a satellite intended to gather definitive information on the earth's magnetic field, on interplanetary magnetic fields, and on the way these fields affect and are affected by the clouds or streams of electrically charged particles, or plasma, thrown outward by eruptions on the surface of the sun. The 78-pound satellite (Fig. 1), named Explorer X (and designated 1961 Kappa for tracking), was launched from Cape Canaveral, Florida, by a Thor-Delta rocket. It was injected into a highly elliptical orbit approximately six minutes later.

Immediately following ascertainment that orbit had been achieved, notification was sent to COSPAR for dissemination to all COSPAR participants. Data obtained by Explorer X will be transmitted to COSPAR and will also be deposited in the IGY World Data Centers.

Orbit

The "window," or period during which the probe could be launched, was restricted to three hours per day on about ten days per month. Only within these restricted periods was it possible to program a trajectory providing the proper relative positions of earth, sun, moon, and payload, such that (i) solar noise would not distort or block out transmissions from the probe; (ii) the optical-aspect system would have proper "look" angles toward the sun, earth, and moon in order to determine the payload's orientation in space for correlation with transmitted data; and (iii) the payload would be in the proper orientation to detect and measure particles emitted from the sun.

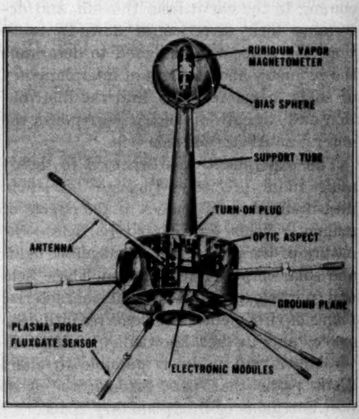

Fig. 1. *Explorer X (1961 Kappa) Magnetometer and Plasma-Probe Satellite, in Cut-Away View. From NASA photograph.*

The orbit calculated to satisfy these conditions, and to obtain representative data on magnetic fields and charged particles in interplanetary space, was a highly eccentric one with an inclination of 33°, apogee of over 100,000 statute miles and perigee of about 105 statute miles. (See Figure 2.) The orbit actually achieved was such that, about 59 hours after launch, Explorer X reached an apogee of about 145,000 statute miles at an azimuth of 140°–150° from the sun-earth direction. Perigee was estimated at about 100 statute miles.

Purpose of Experiment

While this flight was a continuation of scientific investigations made with earlier satellites and space probes, it also was a new effort in many respects. It was the first flight into deep space with a highly accurate rubidium-vapor magnetometer. This absolute instrument also makes possible measurements of hydromagnetic shock waves coming from the sun and impinging on the earth's magnetic field.

The plasma experiment was to obtain measurements of very-low-energy protons coming to the earth from the sun, and determine their direction of flow. In addition, the probe was designed to determine the geometry and strength of interplanetary or solar magnetic fields, and the distribution and strength of electric currents in the outer Van Allen radiation belt.

The experiment was expected to determine more precisely—through total-field measurements and studies of the effects of magnetic fields on charged particles—the nature of the interaction of magnetic fields and solar corpuscular radiation. These field and particle phenomena will characterize man's environment as he ventures into deep space, and further knowledge of this environment will make it possible to chart flight paths that pass through the least hostile regions of interplanetary space.

Instrumentation

The satellite and its instrumentation are shown in a cut-away view in Figure 1. The following is a description of the primary instrumental components.

Rubidium-Vapor Magnetometer: The heart of this payload is the 1.5 pound rubidium-vapor magnetometer, a relatively new, extremely sensitive and accurate instrument. The Explorer X model measures field intensities ranging from .01 to 7000 gammas. It is an absolute instrument—that is, its measurements depend only on fixed constants that do not require calibration.

The rate at which the outer Rb-87 electron revolves around its nucleus is known precisely and would produce a frequency of nearly 7 cycles per second in a weak magnetic field of 0.00001 gauss. The frequency is directly proportional to the field strength —i.e., the stronger the field, the higher the frequency.

This is the way the rubidium-vapor magnetometer works: Light from a small rubidium lamp passes through a filter, lens, and polarizer, and polarized light at a wave length of rubidium then passes into a cell containing rubidium vapor. The light is absorbed by those rubidium-87 atoms having a particular orientation in the cell. When this occurs, the cell becomes opaque to the passage of light, which is detected with a silicon photocell whose output is fed to an amplifier.

As the opaqueness exists for only one-half cycle of the spin of the rubidium atoms, the cell is alternately opaque and transparent at the spin frequency, which is determined by the strength of the magnetic field. This produces a fluctuating light at the photocell which is then amplified and fed back as a small alternating magnetic field, which produces an ordered alignment of the rubidium atoms such that the process will be self-continuing.

Fluxgate Magnetometers: The two flux-

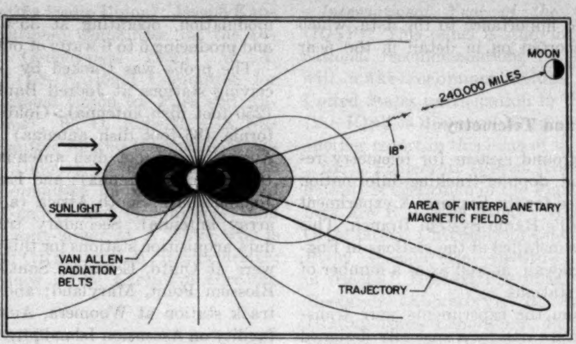
MOON
240,000 MILES
18°
AREA OF INTERPLANETARY MAGNETIC FIELDS
SUNLIGHT
VAN ALLEN RADIATION BELTS
TRAJECTORY

Fig. 2. *Planned Trajectory of Explorer X. The satellite's actual orbit was very close to that shown, providing the desired relative positions of earth, sun, moon, and satellite. NASA photograph.*

gate magnetometers, which weigh about one pound each, are considerably more sensitive than those flown in previous satellites. They are intended to measure fields from 0.5 to 25 gammas and to determine, primarily, the direction of weak magnetic fields. The fluxgate magnetometers are oriented on the payload at a specific angle, such that the spin of the payload makes it possible also to obtain total-field measurements.

Plasma Probe: This instrument, which weighs about 2.5 pounds, is designed to measure the density, direction, and bulk velocity of interplanetary plasma. Positive and negative particles enter the probe through a six-inch circular aperture and pass through a series of grids behind which there is a collector. Owing to this arrangement, the probe is sensitive only to protons with velocities ranging from 6 mi/sec to 1000 mi/sec.

Preliminary Results

Experimental data obtained by Explorer X were transmitted continuously to earth for 60 hours, slightly in excess of the nominal battery life of 55 hours. The scientists responsible for the magnetic field studies by Explorer X, were J. P. Heppner, T. L. Skillman, C. S. Scearce and N. F. Ness, of the Goddard Space Flight Center of NASA. The plasma experiment was conducted by H. S. Bridge, F. Scherb, and B. Rossi, of the Massachusetts Institute of Technology.

At the Forty-Second Annual Meeting of the American Geophysical Union, April 18–21, 1961, the experimenters reported on results indicated by an initial examination of the data. These included: (i) a finding that the interplanetary magnetic field was more intense than anticipated; (ii) detection of large, sudden changes, presumably shock waves, in the magnetic field; (iii) observation of field changes in space at the time of a sudden magnetic-storm commencement at the earth's surface; (iv) measurements of the number densities and velocities of low-energy protons; and (v) a finding that the plasma flux was received primarily from the direction of the sun. The fact that a class 3 solar flare, followed 28 hours later by a sudden commencement, occurred within the 60 hours of battery life gave added importance to the data, which will be reported on in detail in the near future.

Tracking and Telemetry

A new ground system for telemetry reception and doppler-tracking information was designed for the Explorer X experiment by Goddard's Radio System Branch. This system was installed at the stations in England and Hawaii, as well as at a number of Minitrack stations.

Data from the experiments were transmitted to the earth by a specially designed 108-megacycle transmitter employing phase modulation, operating at 35% efficiency, and producing 5 to 6 watts of output power.

The probe was tracked by primary receiving stations at Jodrell Bank, England (250-foot dish antenna); Goldstone, California (85-foot dish antenna); Woomera, Australia (85-foot dish antenna); Hawaii (60-foot dish antenna); and Esselen Park, Johannesburg, South Africa (a 22-db yagi array antenna). Secondary tracking and data acquisition stations for this experiment were at Quito, Ecuador; Santiago, Chile; Blossom Point, Maryland; and the Minitrack station at Woomera, Australia. The facility on Ascension Island provided tracking information.

Geophysics Research Board

The Geophysics Research Board (GRB) was established in 1960 by the President of the National Academy of Sciences, Detlev W. Bronk, in concert with the Governing Board of the Academy. This action was taken partly in response to a request from the International Council of Scientific Unions (ICSU), which had called upon all national science academies to establish a means for their cooperation with the International Geophysics Committee (CIG) of ICSU, and partly in response to expressions of interest by many members of the United States geophysical community. The American Geophysical Union, for example, strongly urged that the Board be established.

Discussions involving many geologists and geophysicists led Dr. Bronk to define the basic functions of GRB as follows: "(1) to effect participation by American scientists in the activities of the new International Committee on Geophysics of the International Council of Scientific Unions; and (2) to stimulate and encourage research interest in the United States in geophysics and related fields, particularly those of an interdisciplinary character. We would look to such a board also to avoid unnecessary duplication and insure full coordination of our several related efforts in these fields."

Membership of GRB

Inasmuch as the membership of CIG is partly made up of designated representatives of the various international unions concerned with geophysics in the broad sense, it was felt that the GRB composition should reflect both the various Academy committees concerned with geophysical problems and the other Academy committees that are counterpart to international committees, thus bringing together the geophysical interests of the Academy and providing an approximate parallel to the CIG.

The membership of GRB is as follows: L. V. Berkner (Space Science Board); Harrison S. Brown (Committee on Oceanography); Michael Ference, Jr. (Committee on Atmospheric Sciences); L. M. Gould (Committee on Polar Research); H. G. Booker (US National Committee for the International Scientific Radio Union); Joseph Kaplan (US National Committee for the International Geophysical Year); M. A. Pomerantz (US National Committee for the International Union for Pure and Applied Physics); W. O. Roberts (US National Committee for the International Astronomical Union); G. P. Woollard (US National Committee for the International Union of Geodesy and Geophysics); and two members-at-large: M. A. Tuve, who is Chairman of GRB, and F. W. Reichelderfer; Hugh Odishaw is the Executive Director.

Panels of GRB

In order to consider specific international programs now being promulgated by CIG, the GRB established four panels, as follows:

World Magnetic Survey (WMS): This panel is charged with considering the international recommendations on the WMS (a description of the WMS will appear in a forthcoming issue of the *Bulletin*) and to make recommendations for United States participation in the program. Technical supervision of the WMS is under the International Association of Geomagnetism and Aeronomy (IAGA) while international coordination is being handled by the CIG. The WMS period has been set for 1964–65, when the minimum of solar activity is expected to occur. Measurements being made now will also be useful for WMS as they can be reduced to epoch 1965 through knowledge of the rate of change of the magnetic-field elements.

E. H. Vestine (RAND Corporation) is Chairman of the Panel; its members are L. R. Alldredge (US Coast and Geodetic Survey), J. R. Balsley (US Geological Survey), B. C. Byrnes (US Navy Hydrographic Office), J. P. Heppner (National Aeronautics and Space Administration), J. H. Nelson (US Coast and Geodetic Survey), and Victor Vacquier (Scripps Institution of Oceanography); Secretary, Stanley Ruttenberg (NAS).

International Year of the Quiet Sun (IQSY): This panel is studying the international recommendations for IQSY, and will make recommendations regarding United States participation in the program (the IQSY is discussed in greater detail in another report in this issue of the *Bulletin*).

M. A. Pomerantz (Bartol Research Foundation) is Chairman of the Panel; its members are R. Grant Athay (High Altitude Observatory, University of Colorado), C. T. Elvey (Geophysical Institute, University of Alaska), Herbert Friedman (US Naval Research Laboratory), R. A. Helliwell (Radioscience Laboratory, Stanford University), Joseph Kaplan (University of California at Los Angeles), Sadami Matsushita (High Altitude Observatory), Alan Maxwell (Radio Astronomy Observatory, Harvard University), Peter Meyer (Enrico Fermi Institute for Nuclear Studies, University of Chicago), H. V. Neher (California Institute of Technology), E. P. Ney (University of Minnesota), H. E. Newell, Jr. (National Aeronautics and Space Administration), J. A. Van Allen (State University of Iowa), A. H. Waynick (Pennsylvania State University); Secretary, Stanley Ruttenberg (NAS). Two meteorologists will be added to the Panel.

International Exchange of Scientific Data: This panel is concerned with the CIG recommendations regarding the exchange of geophysical data: these involve, first, completion of the IGY/IGC exchange; second, examination of the needs for the period 1960–63; and third, planning for exchange of data accumulated during the WMS and IQSY, 1964–65. The CIG itself now has underway a critical review of the data exchange, discipline-by-discipline, with a view toward eliminating exchange of data that are no longer useful and including data from new types of observations or experiments. The CIG is looking to its reporters in each geophysical discipline and to the various international unions for advice and recommendations on data exchange.

This GRB panel is seeking the opinions of United States Scientists on what might be the most useful exchanges to carry out, and is also studying the structure of World Data Center A in terms of how the various sub-centers can best complete their IGY/IGC responsibilities and carry out the recommendations that will be developed by CIG for data exchange in the coming several years.

A. H. Shapley (CRPL, National Bureau of Standards) is Chairman of the Panel; its members are L. R. Alldredge (US Coast and Geodetic Survey), A. J. Dessler (Lockheed Aircraft Corporation), J. P. Heppner (NASA), J. A. Lockwood (University of New Hampshire), Hugh Odishaw (National Academy of Sciences), and Harry Wexler (US Weather Bureau); Secretary, Pembroke J. Hart (NAS).

Solid Earth Problems: This panel was organized in cooperation with the Earth Sciences division of the Academy, partly in response to the CIG proposal for an international program on the upper mantle of the earth (this program will be described in a future issue of the *Bulletin*), and partly in recognition of the opportunity that has developed in recent years to advance substantially our understanding of the nature of the solid earth. The Panel consists of two working groups.

G. P. Woollard (University of Wisconsin) is Chairman of Working Group 1; its members are L. T. Aldrich (Department of Terrestrial Magnetism, Carnegie Institution of Washington), Francis Birch (Harvard University), James Gilluly (US Geological Survey), H. H. Hess (Princeton University), H. L. James (US Geological Survey), Leon Knopoff (University of California at Los Angeles), Walter Munk (Scripps Institution of Oceanography), J. E. Oliver (Lamont Geological Observatory), Frank Press (California Institute of Technology), and John Verhoogen (University of California, Berkeley); Secretary, Linn Hoover (NAS).

H. S. Yoder, Jr. (Geophysical Laboratory, Carnegie Institution of Washington) is Chairman of Working Group 2; its members are Allen Cox (US Geological Survey), W. H. Diment (US Geological Survey), James Dorman (Lamont Geological Observatory), C. L. Drake (Lamont Geological Observatory), R. A. Haubrich (Scripps Institution of Oceanography), J. H. Healy (California Institute of Technology), Robert Meyer (University of Wisconsin), T. H. McCulloh (University of California, Riverside), John Steinhart (Department of Terrestrial Magnetism, Carnegie Institution of Washington), and J. B. Thompson (Harvard University); Secretary, Linn Hoover (NAS).

Origin of Subvisual Red Auroras

The following material is based on a more-detailed report by G. A. M. King and F. E. Roach, published in the March-April 1961 issue of the Journal of Research—D. Radio Propagation, *of the National Bureau of Standards.*

On the night of November 27–28, 1959, magnetic and auroral activity occurred over a large part of the United States. Visual observers, especially in the northwestern United States, reported auroral structure during the event, and, in particular, bright auroral activity with red in the northern sky was seen from Boulder, Colorado, at about 0600 UT.

Instrumental coverage was excellent, and included (1) all-sky camera observations; (2) photometric observations of the green (5577 A) and the red (6300 A) auroral lines at three stations in the southwestern United States; (3) ionospheric soundings, with special recordings near Boulder in the low-frequency range (50 kc/s to 2 mc/s); and (4) measurement of fluxes of high-energy particles in the outer Van Allen zone during several passes of the Explorer VII satellite.

This report discusses the relationship between photometric observations of a subvisual red arc and ionospheric soundings. The authors hypothesize that the red emission is due to enhanced ionospheric recombination; they draw semi-quantitative support for this hypothesis from the observational data.

(*Bulletin No. 36* describes the subvisual monochromatic red arcs and discusses some early observations of them made during the IGY; *Bulletin No. 45* reports on correlations between photometric, visual, and satellite observations of both visual and subvisual auroral activity and of changes in the Van Allen radiation belt during the November 1959 event discussed in the present report.)

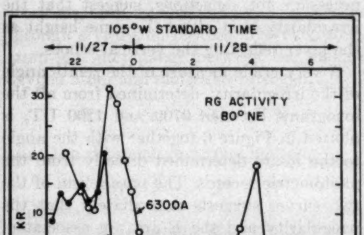

Fig. 3. *Intensity Changes in Visual (RG) and Subvisual (R) Auroral Activity during the Night of November 27–28, 1959. The RG activity was near northeast horizon, as seen from Fritz Peak, while the R-arc was higher in the sky (as shown in Figure 4).*

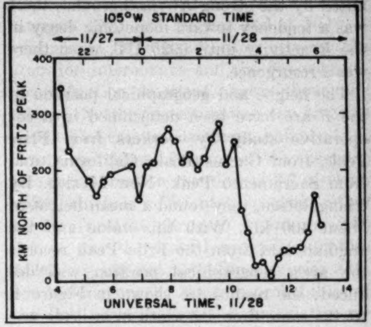

Fig. 4. *Position of R-Arc Relative to Fritz Peak on November 27–28, 1959. Assumed height of arc was 400 km.*

Photometric Observations

Photometric observations were made at Fritz Peak, Colorado, from 0410 UT to 1310 UT (9:10 pm–6:10 am local time), November 27–28, 1959, in three wave lengths, 5577 A [OI], 6300 A [OI], and 5893 A [NaI]. The forbidden oxygen radiations (5577 A and 6300 A) were active throughout the night. Two classes of activity occurred, and for convenience they are classified as follows: (1) *RG*, in which both the red (6300 A) and the green (5577 A) emissions are enhanced in intensity; (2) *R*, in which the emission forms an arc selectively enhanced in the red and with no apparent increase in the intensity of the green emission. It is tempting to think of *RG* as regular auroral activity, since both the red and green lines are characteristic features of auroras in general.

On this particular night, the *RG* activity covered a wide range of intensity (see Fig. 3), while the *R* activity went through slow and ponderous changes. The general impression from Figure 3 is that after 0700 UT, when the *R* data were no longer contaminated by the strong *RG* background, there was a tendency toward monotonic decay in the *R* activity until 0925 UT, when there was a resurgence.

The height and geographical position of the *R*-arc have been determined in a cooperative study by workers from Fritz Peak, from Cactus Peak, California, and from Sacramento Peak, New Mexico. By triangulation, they found a mean height of about 400 km. With this value and the angular data from the Fritz Peak records the arc's geographical position was deduced; the results are shown in Figure 4. At the same time, its width in latitude was determined to be about 500–600 km.

Ionospheric Data

Ionospheric records were taken half-hourly at Boulder, 26 km from Fritz Peak. Figure 5 shows diagrammatically the salient features of the ordinary-wave reflections shown in the ionogram for 0730 UT.

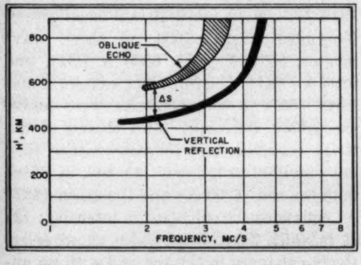

Fig. 5. *Diagram Showing Essential Features of Ionogram for 0730 UT, November 28, 1959, at Boulder, Colorado.*

A conspicuous feature of this ionogram is the spread echo above the main trace. As the F region totally reflects all waves traveling vertically in this frequency range, it is not possible for the spread echo to be overhead at a greater height than the normal F layer; therefore, the spread trace must be due to echoes received obliquely from a large irregularity in the F layer at some distance from the observing station. Further considerations, based on the conditions necessary for reflections, suggest that the irregularity is at about the same height as the layer reflecting the vertical echoes.

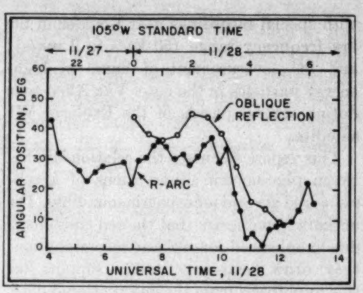

Fig. 6. *Angular Positions of R-Arc and Oblique Radio Echo Observed on November 27–28, 1959. It is thought that the oblique echo was reflected from a large irregularity in the F layer of the ionosphere at some distance from the station.*

A very crude measure of the zenith angle of the irregularity, determined from all the ionograms between 0700 and 1200 UT, is plotted in Figure 6 together with the angle to the *R*-arc determined directly from the photometric records. The parallelism of the two curves suggests immediately that the irregularity and the *R*-arc are associated, especially in view of the fact that the height of the arc places it in the F region. This conclusion has been reinforced by a study of the temporal association of oblique echoes and *R*-arcs, using ionograms from Fort Monmouth, New Jersey, White Sands, New Mexico, and Boulder, Colorado, for nights in September 1957 and December 1959.

An important observation that can be made from Figure 5 is that the electron density in the irregularity is *lower* than in the overhead trace. In other words, the *R*-arc is associated with a local *decrease* in the ionization of the F region.

Relationship of the Red Emission to Ionospheric Recombination

In order to understand the origin of the red arcs, four observational facts must be explained; they are: (1) the occurrence of the *R*-arc after the main phase of a magnetic disturbance; (2) the steady change of intensity with time; (3) the strong emission of the red lines of atomic oxygen without measurable emission of the green oxygen line; and (4) the association of the *R*-arc with a local decrease in the ionization of the F region.

In the normal process of recombination in the ionosphere, electrons are produced during the daylight hours by photo-ionization of atomic oxygen, as follows:

$$O + h\nu \rightarrow O^{+} + e.$$

As the reverse process of radiative recombination is extremely slow, the removal of electrons, both by day and by night, occurs through a two-step process involving, first, atom-ion interchange between the ionized oxygen atom and molecular nitrogen,

$$O^{+} + N_2 \rightarrow NO^{+} + N,$$

and then dissociative recombination,

$$NO^{+} + e \rightarrow N^{*} + O$$

or

$$NO^{+} + e \rightarrow N + O^{*}.$$

(The asterisk indicates that the particle is in an excited, or metastable, state but carries no electric charge.) Similar reactions involving molecular oxygen appear to be unimportant for the present purpose.

The second-step equation gives a relationship between recombination and upper-atmospheric emissions; the products of the recombination are excited atoms of nitrogen or oxygen, and when they decay to the ground states they emit characteristic radiations at 5199 A [NI] and 6300 A (and 6364 A) [OI].

If the distributions with height of both the electrons involved and the molecular nitrogen (N_2) are known, and if NO^{+} is assumed to be in equilibrium between the atom-ion interchange and the dissociative-recombination reactions shown above, the rate of electron recombination can be computed. The exothermic energy balance (i.e., involving release of heat) of the dissociative-recombination reaction is 2.7 electron volts, which is sufficient to provide either an NI (neutral nitrogen) quantum (2.36 ev) or an OI (neutral oxygen) quantum (1.96 ev), but not both. Since precise data are lacking on the relative probability of the two variations of the dissociative-recombination reaction shown above, it is assumed that one OI quantum is emitted for every two recombinations.

Applying this theory to the calculation of the red emission on a "quiet" night, a rate of 10^{-4}/sec at 300 km was assumed for the atom-ion interchange reaction, and a rate coefficient of $2 \times 10^{-8}/\text{cm}^3/\text{sec}$ was adopted for the dissociative recombination reaction. Figure 7 compares the electron-density profile and the deduced 6300 A emission profile for the ionogram taken at 0730 UT, November 19, 1958. The integrated emission intensity of 28 rayleighs agrees well with previously observed values for quiet nights, and, in fact, D. Barbier obtained a value of 30 rayleighs for 0700 UT on the same night at the Haute Provence Observatory, France. (A weak, or faint, visual aurora in 6300 A radiation would have an intensity of at least 6000 rayleighs.) The height of the night airglow, at 6300 A, has not yet been measured, but available evidence places it in the F region (above about 170 km) of the ionosphere. In this example, a height of 260 km was deduced for the maximum emission.

To determine whether the same theory could explain the *R*-arc on the night of November 28, 1959, a direct comparison can be made between the theory and uncorrected observations. It is assumed that the abnormally great brilliance of the *R*-arc

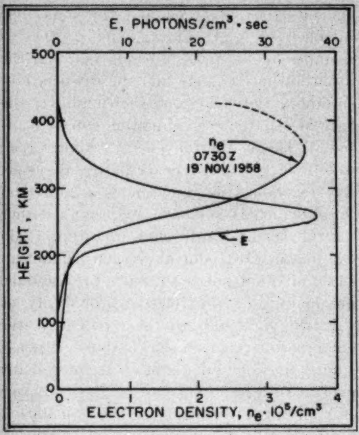

Fig. 7. *Profiles of Electron Density and 6300 A Emission under Quiet Conditions, 0730 UT, November 19, 1958.*

is due to enhanced recombination: i.e., that β, the rate-coefficient of atom-ion interchange between O^+ and N_2 for any density of N_2, is larger than its normal value such that the calculated emission agrees with the observed emission. The test of the theory, then, is based on comparison of the predicted and the observed heights of maximum emission.

For the electron-density profile at 0730 UT, November 28, 1959, almost perfect agreement is reached if, at a height of 300 km, $\beta = 10^{-1}$/sec. The electron-density profile and the emission profile are shown together in Figure 8. In a comparison of all of the five times on this date for which studies were made, the nearest approach to agreement also occurs when β_{300} is about 10^{-1}/sec. The effect of varying the rate coefficient for dissociative recombination between 10^{-8} and 10^{-7} cm³/sec was studied, and 2×10^{-8} gave the best over-all agreement.

Reason for Increased Recombination

The rate of recombination required to give agreement between the theory and the observations is 1000 times the normal rate. This factor is so large that, in spite of the fair success of the theory, one must ask if it is reasonable.

The recombination rate, β, is proportional to $[N_2]$. Normally, at 300 km, $[N_2]$ makes up about one-thirtieth of the total number of atmospheric particles; this figure is based on a diffusion level of 105 km, which is in agreement with rocket observations. However, during auroral activity the atmosphere is heated by the influx of energetic particles. Direct evidence of this has recently been provided by T. M. Mulyarchik, who measured the temperature of the region emitting the 6300 A OI line; he found that the temperature increased with the brightness of the display.

Under normal conditions, the F region is hotter than the E region. Most of the energy of the aurora is set free in the E region, however, and if the increase in F-region temperature is due to conduction of heat from the E region, the normal temperature gradient would have to be reversed. This would call for a very great rise in the E-region temperature, and consequent great changes in atmosphere densities at all higher levels. Another consequence of interest here is the mixing caused by this reversal of the temperature gradient; this mixing raises the diffusion level and increases the fractional molecular concentration at higher levels. Thus, during and after auroral activity, we would expect to find a great increase in $[N_2]$ at F-region heights, and a factor of 1000 does not seem unreasonable.

Three other facts deserve mention in this respect. The first is that the electron-density profiles on November 28, 1959, are consistent with atmospheric scale heights in the F region 1½ times normal. Next, satellite drag data indicate an increase in

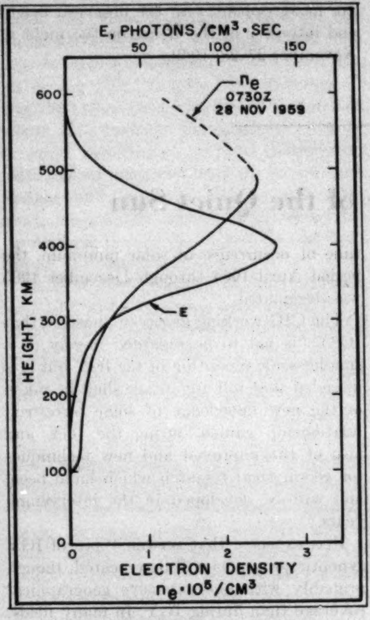

Fig. 8. *Profiles of Electron Density and 6300 A Emission on Night of November 28, 1959 (0730 UT), under Conditions of Auroral Activity.*

atmospheric densities at times of magnetic storms. Finally, E. A. Lytle and D. M. Hunten report that at dawn after an active aurora the N_2^+ emission was very greatly enhanced; while they explain this simply in terms of resonance scattering from N_2^+ ions generated by the aurora, it seems to the NBS investigators more likely, in view of the rapid recombination of N_2^+, that the ions were generated by solar ultra-violet light, and that the difference between this and normal dawn lies in the increased $[N_2]$.

Further Discussion

Accepting the ideas of the last section, it must be asked what effect such a large change in the atmosphere would have on the computation of 6300 A emission according to the theory outlined previously; clearly, the $[N_2]$ profile should not be derived in the simple manner used for quiet-night conditions. A trial calculation, based on scale heights greater by a factor of 1½ than those adopted previously (a preliminary model atmosphere computed by H. K. Kallmann and M. L. Juncosa on the basis of rocket and satellite data) shows that the emission profile is thickened, but that the height of maximum emission is not greatly altered; more important, however, is that the value of β_{300} needed to give the observed emission is decreased to only 400 times the normal value. As mixing also increases the effective scale height of $[N_2^+]$, it is likely that on the night of November 27–28, 1959, the increase in β_{300} was much less than the 1000 times deduced earlier. The data do not justify a more complete analysis to determine the increase precisely.

Summary

To explain the origin of subvisual monochromatic (6300 A) red auroral arcs, the NBS investigators have submitted a hypothesis based on the excitation in the upper atmosphere of the oxygen atom to the ^1D energy state. The proposed mechanism involves (1) an atom-ion interchange in which O^+ and N_2 go to NO^+ and N, and (2) a dissociative recombination in which NO^+ and an electron yield excited atomic nitrogen or oxygen. The dissociative recombination is sufficiently exothermic (2.72 ev) to excite the oxygen atom to the ^1D energy state (1.96 ev) but not to the more-energetic ^1S state (4.16 ev).

To account for the strong emission of [OI] at 6300 A in the form of arcs on the equatorward side of general auroral activity, it is hypothesized that during an aurora the rate of the atom-ion interchange is increased by a large increase in the density of molecular nitrogen at F-region heights as a consequence of heating of the atmosphere below and subsequent vertical mixing. The predictions of the hypothesis are in agreement with the observed height and intensity of the R-arc on the night of November 27–28, 1959.

International Year of the Quiet Sun

Solar and geophysical studies during IGY/IGC advanced our understanding of the many phenomena in the earth's atmosphere and in near space that are influenced by solar disturbances, and uncovered many new features of the atmosphere and of solar-terrestrial couplings. The success of the IGY/IGC program led IGY scientists to continue, on a less formal basis, many upper-atmosphere and solar observations. It was thought that most of them should extend at least through the waning portion of the solar cycle. In addition, the suggestion was made that certain types of observations should be repeated in a "little IGY," during the time of minimum solar activity so that some solar-terrestrial couplings at times of both maximum and minimum solar activity could be compared.

As a result of these views, a program at first called "The Solar Activity Minimum Program" was suggested. At an informal meeting of the International Committee on Geophysics (CIG) of ICSU, held at the time of the XIIth General Assembly of the IUGG, in Helsinki, August 1960, this program was discussed and a working group appointed to bring together the viewpoints of specialists in the upper-atmosphere and solar disciplines.

At the last meeting of the CIG, in Paris, January 1961, this program was discussed further and officially adopted as a CIG sponsored international program. The name "International Year of the Quiet Sun," or IQSY, was adopted and, upon the advice of the solar experts concerning the probable time of occurrence of solar minimum, the period April 1964 through December 1965 was designated.

The CIG working group emphasized that IQSY "is not to be regarded merely as a smaller scale repetition of the IGY but it is intended that full advantage shall be taken of the new knowledge of solar terrestrial relationship gained during the IGY and also of the improved and new techniques for geophysical research which have been, and will be developed in the intervening years."

It is expected that certain types of IGY synoptic programs will be repeated, though probably with less extensive geographical coverage than during IGY. In many fields, new experiments are being suggested stemming from new knowledge gained from the IGY and also from the fact that certain experiments and observations will be possible that could not have been made during the maximum portion of the cycle.

Preliminary International Program Recommendations

Based on the preliminary discussions at the informal meeting of CIG in Helsinki, the work of the various discipline reporters, and advice from some of the scientific unions interested in geophysical work, a preliminary statement of the IQSY program was developed at the Paris meeting, which may be summarized as follows:

World Days: As during the IGY, there will be an International Geophysical Calendar with some Regular World Days and Intervals selected in advance. There will also be Alerts and Special World Intervals, as during IGY, to take full advantage of any important solar disturbance that should occur. It is expected that there will also be a rapid interchange of solar geophysical data among interested workers, as was done during IGY. (*Bulletin Nos. 42* and *47* report, respectively, on the most recent International Geophysical Calendar and most recent plan for World Days.)

Solar Activity: One of the key programs of IQSY will be a global solar patrol of the type that was instrumental in the success of the IGY. This program is important not only from the point of view of upper-atmosphere and space studies related to solar disturbances, but for an understanding of the sun itself. The quiet sun forms the easiest starting point for theoretical studies and provides an opportunity to investigate individual disturbances that are often far more complex near the time of solar maximum. Visual photographic and radio patrols will provide data for the issuance of Alerts and SWI and for rapid interchange among workers.

CIG suggested that the Solar Activity Data Centers should undertake to review the data they receive and offer comments to the collectors with a view to achieving greater uniformity in the reporting of solar data. Rocket and satellite techniques should increase the amount of solar data available. Recommendations were also made with reference to improving the services of the *Quarterly Bulletin of Solar Activity* and to expanding participation in the work of preparing daily solar maps.

Geomagnetism: Recommendations were made to continue the observation of time variations of the geomagnetic field and of earth currents. It was suggested that the present network of stations should be supplemented by additional locations, in particular in the auroral zones (near about 70° N and S geomagnetic latitude) and poleward from them, where geomagnetic activity responds clearly to weak solar corpuscular radiation. Rapid-run variometers should be installed to record the details of magnetic storms, which will undoubtedly be less frequent than during IGY, and perhaps less complex, and hence may offer a better possibility of understanding their morphology.

Aurora: During sunspot minimum the aurora is greatly changed from that of sunspot maximum. There are still auroras almost every night in the auroral zones but they do not develop and spread southward as so often happens during periods of sunspot maximum, such as the IGY; there will probably be very little auroral activity observed at latitudes much lower than the auroral zones.

A much smaller network of stations than for the IGY should serve to monitor the occurrence of aurora during the IQSY, but it is expected that many special experiments will be undertaken concerning the differences between auroral forms and activity at solar minimum as contrasted with maximum. One specific experiment that has been emphasized is establishment of comprehensive interdisciplinary observing programs at pairs of magnetic conjugate points. The observations should include a full complement of optical auroral observations, radar observations, ionospheric absorption studies, measurements of magnetic fluctuations ranging from the standard type into the sub-audio frequencies, vertical-incidence ionosoundings, and cosmic-ray intensity measurements.

Airglow: Airglow observations will be particularly important during solar minimum because of the absence of auroral contamination outside the auroral zones. Consequently, airglow studies for IQSY may represent an increase over those of the IGY.

The CIG group made a number of recommendations concerning the specific airglow emissions to be studied, and recommended that chains of stations be installed to study the OH emission bands and the NA-D twilight emission. It was suggested that aircraft be used for the study of the geographical distribution of the 6300 Å arcs (these arcs are discussed in another report in this issue of the *Bulletin*) and other airglow features.

Ionosphere: It was recommended that synoptic-type programs be repeated for comparison with IGY observations, although it was recognized that it may not be necessary for the IQSY station network to be as complete as that of the IGY in order to determine and study the solar-cycle effects. New techniques should be exploited to follow up new knowledge of the ionosphere gained during and since the IGY, with emphasis on ionospheric studies for which change in solar activity is an important factor.

A number of important ionospheric-physics studies of problems that are mostly unsolved were listed for emphasis during IQSY, including, for example, sounding of the upper side of the F region by rockets and satellites; investigation of geomagnetic control of the ionosphere; investigation of absorption processes in the lower ionosphere; investigation of dynamic processes; continuation of the study of the physics and chemistry of formation and maintenance of regular ionospheric layers; investigation of the state and development of the ionosphere over the polar caps; and study of irregularities in electron distribution in the very high ionosphere and exosphere.

Cosmic Rays: It was recommended that the international network of cosmic-ray stations should continue, through the IQSY period, regular observations on the level of those of the IGY. Studies of low-energy primary cosmic rays and of the cosmic-ray equator may be particularly fruitful during solar minimum. The solar minimum period should also provide opportunity to study sidereal cosmic-ray variations and, since the solar variation of primary cosmic-ray intensity is expected to be small during the IQSY, there is an excellent opportunity to investigate atmospheric effects on cosmic-ray intensities at ground level.

Investigation of the great belts of geomagnetically trapped radiation surrounding the earth will be of considerable importance, particularly with regard to determination of the positions of the belts in space and of the nature and energy distributions of the particles constituting these belts.

Space Research: The CIG looks to the Committee on Space Research, COSPAR, for assistance in developing recommended programs for rockets, satellites, and space probes during IQSY. (These questions were considered at the meeting of COSPAR, in Florence, Italy, April 1961, and a series of recommendations was developed that include observations of magnetic fields and particles in interplanetary space and exploration of current systems in the earth's atmosphere and beyond.)

In addition, the CIG suggested for inclusion in the IQSY, studies of the intensity and polarization of the zodiacal light in order to determine the distribution of dust and other material in interplanetary space in the neighborhood of the earth; measurements of magnetic-field intensities and variations in interplanetary space; and studies of phenomena in the terrestrial atmosphere associated with hydromagnetic waves.

Aeronomy: It is desirable to measure many parameters in the upper atmosphere, including pressure, density, concentration of various constituents, identification and concentration of positive and negative ions, and electron densities. New techniques, it was suggested, must be introduced to obtain vertical distribution of mean molecular mass and mean molecular temperature. Spectral observations of the extreme ultraviolet radiation of the sun should be included so as to obtain complete solar data.

Among the specific recommendations for inclusion among IQSY programs are measurement of the absolute energy values and spectral distribution of solar radiation; of atmospheric absorption of solar radiations for various spectral ranges; and of the specific absorption of various constituents. To determine the real solar significance of the various solar indices, it was recommended that solar ultraviolet spectra be obtained by rockets up to the altitude of zero optical depth and that absolute intensities of lines be measured through the entire ultraviolet spectrum. To obtain the spectrum of the quiet sun for comparison with that during disturbed conditions, it was recommended that the sun's ultraviolet and X-ray spectra be monitored from satellites.

GRB Panel on IQSY

In order to provide a means for planning United States participation in the IQSY, a Panel on IQSY was established by the Geophysics Research Board (GRB) of the US National Academy of Sciences, as described in another report in this issue of the *Bulletin.* At its first meeting, in April 1961, GRB's Panel on IQSY endorsed the recommendations of the CIG as a basic guide for the international program, and recommended some extensions and modifications.

Meteorology: The Panel expressed a desire to include some meteorological studies in the IQSY program, and suggested that attention be given to various possibilities for special observations. It was recommended that two meteorologists be invited to join the Panel to ensure coverage of meteorological observations in the US program.

Timing of the Program: The panel felt strongly that the IQSY should be planned so that observations would be well under way in advance of the arrival of solar minimum. It was pointed out that high-activity cycles tend to be shorter than average, and that the IGY cycle was the highest yet observed. It is therefore considered possible that the approaching solar minimum may occur earlier than expected. An advance-test year was proposed for 1963 so that as many observations as possible could be started as a safeguard should minimum occur early. This would also enhance the value of certain observations that should be made well in advance of minimum.

US-IQSY Programs: The GRB Panel discussed the specific program recommendations made by CIG and COSPAR, not only in terms of the international program but in terms of the interests of United States scientists as well. In order to develop the US program, the Panel feels it desirable to inform as wide a segment as possible of the US geophysical community, and to seek information on:

(i) Programs that might contribute to the objectives of the IQSY, but which are already definitely planned and expect to receive support during the IQSY period.

(ii) Additional programs that might be supported through regular channels.

(iii) Research programs or experiments that might be significant contributions to IQSY, but which are of such a nature that direct collaboration or coordination is required on an international level, or which are too large in magnitude for regular geophysical programs of the various support agencies.

The IQSY Panel is also considering possible contributions to the program by amateur groups, such as radio amateurs, auroral observers, and the various amateur satellite tracking groups active during the IGY. Suggestions on these matters would be welcomed by the Panel and should be addressed to the Secretary, IQSY Panel, Geophysics Research Board, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C.

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